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Layaway Procedures for U.S. Army Facilities, Volume I: Decision Criteria and Economics

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This two-volume report describes facility layaway procedures for U.S. Army facilities, with an emphasis on Fort Dix, New Jersey.

Volume I focuses on decision criteria and the economics of facility layaway. Decision matrices for choosing cost-effective layaway strategies are presented. The concepts behind differing maintenance and repair (M&R) standards are addressed. Strategies for both short- and long-term layaway periods are described. The influence of the allowed reactivation period on M&R strategies is also described. Deactivation, periodic M&R, and reactivation for buildings and utilities are discussed, as are environmental and security concerns.

Volume II addresses the specific inspection and maintenance and repair items associated with all of the different systems and components for buildings and utilities. These items are presented in a checklist format. A brief explanatory section precedes each checklist.

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This two-volume report describes facility layaway procedures for U.S. Army facilities, with an emphasis on Fort Dix, NJ.

Volume I focuses on decision criteria and the economics of facility layaway. Decision matrices for choosing cost-effective layaway strategies are presented. The concepts behind differing maintenance and repair (M&R) standards are addressed. Strategies for both short- and long-term layaway periods are described. The influence of the allowed reactivation period on M&R strategies is also described. Deactivation, periodic M&R, and reactivation for buildings and utilities are discussed, as are environmental and security concerns. The report concludes that facility layaway is technically feasible at an affordable cost.

Volume II addresses the specific inspection and M&R items associated with all of the different systems and components for buildings and utilities. These items are presented in a checklist format. A brief explanatory section precedes each checklist.

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FOREWORD

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LAYAWAY PROCEDURES FOR U.S. ARMY FACILITIES, VOLUME I: DECISION CRITERIA AND ECONOMICS

1 INTRODUCTION

Background

Base closure and realignment[1] is causing significant changes in mission and population at several Army installations. Within the U.S. Army Training and Doctrine Command (TRADOC), several forts are being affected, but the greatest mission change is occurring at Fort Dix, NJ. There, the mission has been changed to primarily support Army Reserves and provide a site for mobilization training capabilities. This new mission is leaving vacant many facilities that have been regularly occupied. TRADOC plans to use these facilities intermittently to accommodate surges of Reserve component training each year. Other facilities must be maintained for occupancy on short notice as mobilization training requirements develop months or years from now. This affects hundreds of thousands of square feet of building space. Existing regulations[2] address some procedures, but do not provide comprehensive guidance for layaway (deactivation, periodic maintenance and repair, and reactivation) of specific buildings or building groups with their related utility networks and grounds for the lowest life-cycle cost in maintaining and operating those facilities. Neither do any other Army documents provide the necessary guidance.

The U.S. Army Construction Engineering Research Laboratory (USACERL) was tasked by TRADOC to develop layaway procedures on a life-cycle cost basis, with an emphasis on the facilities at Fort Dix.

Objective

The objective of this study is to develop procedural facility layaway guidelines, based on the lowest life-cycle cost, for individual buildings, building groups, related utility networks or subnetworks, and surrounding grounds.

Volume I describes the decision criteria and economic considerations involved in developing the guidelines. Volume II presents the procedures and checklists for each facility component.

Approach

Background information on the problem was gathered, although there was little available. A variety of Fort Dix site-specific facility information was reviewed, site visits were made to Fort Dix, and all available technical literature was studied. This included literature from equipment manufacturers, material suppliers, government agencies, and appropriate trade journals. Organizations known to be involved with facility layaway were contacted and interviewed. These organizations included U.S. Army Materiel

[1] *Base Realignments and Closures: Report of the Defense Secretary's Commission* (Department of Defense, December 1988).
[2] Army Regulation (AR) 210-17, *Inactivation of Installations* (Headquarters, Department of the Army [HQDA], January 1967).

Command (AMC), the U.S. Navy, the National Park Service (NPS), the National Aeronautics and Space Administration (NASA), and others. Finally, studies performed by other government laboratories were reviewed.

A checklist of procedures was identified for each different type of facility component and material. The approach taken divided the facilities into two distinct groups: buildings and utility systems. Then, each group was further divided into specific components. The intent was to make the component checklists as generic as possible to facilitate use at other installations. However, since the focus of the study was Fort Dix, components and/or materials present at other installations but not subject to layaway at Fort Dix are not included. These checklists incorporate existing state-of-the-art technologies for facility layaway. This project did not include research into new and innovative methods.

A matrix approach was integrated with the checklists. The matrix incorporated the decision variables of length of the layaway period, allowed reactivation time, and three levels of maintenance and repair (M&R) activity. The life-cycle cost analyses were based on those variables. The specific costs used in the analyses pertain to Fort Dix. Geographical and climatic variables, outside of those applicable to Fort Dix, were not considered in developing the checklists.

Facility issues specifically or uniquely applicable to Fort Dix were studied to provide a complete analysis necessary for a proper layaway plan.

Scope

This report addresses the procedures for the layaway of U.S. Army facilities. These include tasks associated with deactivation, periodic M&R, and reactivation. The procedures are applicable to the variety of facilities scheduled for layaway at Fort Dix, and to facilities at other locations with similar climate. The procedures are supplemented and supported with cost analyses. Where appropriate, explanations are given on the assumptions used and the methods employed.

Because of the complexity of developing the needed guidelines and the short timeframe specified by TRADOC, this study should be considered a Phase I effort that identifies and consolidates existing technologies into a single package, with main emphasis on Fort Dix.

Mode of Technology Transfer

This report has been prepared in two volumes to assist in the technology transfer process. Volume I is intended primarily for installation and Major Command (MACOM) managers and budgeteers in developing strategies and deciding "big picture" issues. Volume II is intended for facility inspectors, planners, estimators, and others in identifying specific work items, preparing work orders, and preparing contracts. Some topics in Volume I should also be of interest to those same people.

Since this report is not comprehensive in terms of facility and component types addressed, technology transfer through a Department of the Army Technical Manual or Pamphlet, or through a similar MACOM publication, is not recommended. If and when layaway procedures are developed for additional kinds of facilities and locations representative of the Army as a whole, incorporation into a technical manual or pamphlet would be recommended.

2 DECISION MATRIX DEVELOPMENT AND USE

The procedures that should be employed to properly lay away a facility on a cost-effective basis depend on a number of variables. A method is needed that allows the decisionmaker to consider those variables when planning an M&R strategy over the layaway period. A simple decision matrix provides that method. A proposed matrix is given at the end of this chapter, after a discussion of the variables that must go into the matrix.

Variables

The key variables considered in this study are:

- Deactivation period
- Reactivation period
- "Heat" and "no heat" alternatives
- Facility type and use
- Material and equipment inventory
- Climate
- Maintenance standards
- Life-cycle costs.

Each of these is discussed below.

Deactivation Period

The length of time that a facility will lay dormant is a key factor in developing M&R strategies. This is due to the cyclic nature of M&R activities. Generally, performed M&R will serve its intended purpose for a minimum of 1 year. Beyond that, however, effectiveness diminishes, resulting in the need to perform it again. The frequency of a given M&R application depends on the facility, component, material, initial condition, level of M&R performed, quality, climate, and a host of other factors. If that frequency is less than the specified deactivation period, the need for the M&R activity becomes questionable. Activities needed to preserve the facility clearly must be done, but the necessity of others becomes a subjective judgment. M&R frequency factors, when coupled to a variable or unknown reactivation period, lead to the nearly impossible task of developing M&R strategies tied to any specific interval of time. If, however, strategies are considered on a more general basis, the task becomes manageable. When the facilities are considered in terms of "short" and "long" layaway periods, practical and usable strategies can be developed.

A short layaway period is defined to be 1 year or less. The basis for this definition is to accommodate the annual scheduling of reservists occupying a portion of the deactivated facilities. A short layaway

period can be used to provide a planned rotation of deactivation and reactivation procedures to enhance the longevity of the facilities through appropriate M&R investment.

Long-term layaway is considered to be greater than 1 year. Since "long-term" becomes open ended by that definition, a 10-year target was used as the benchmark to plan M&R needs and budgets. Ten years is a practical definition because no one really knows when the facilities, if ever, will be needed, and many components exposed to the elements will reach the end of their expected lives at that time. If, toward the end of that period, it appears that the facilities will continue to stand idle, then a complete condition and M&R strategy evaluation should be undertaken to map out the needs for the next decade.

Both the short- and long-term layaway scenarios require scheduled M&R to combat anticipated annual deterioration of the facilities' components.

Reactivation Period

The reactivation period is also a critical variable. This relates to the required readiness state of the facility and level of M&R needed to sustain that readiness. The shorter the reactivation period desired, the higher the sustained readiness state must be because of the shortage of time available to perform deferred M&R. A higher readiness state requires performing more periodic M&R during layaway and deferring less to the reactivation phase.

A critical factor in selecting appropriate periods for which to establish M&R strategies is the need to supply steam to the various buildings for heat and other purposes. Once boiler plants are deactivated, a minimum of 45 days is needed to restore them to an operational condition. This 45-day juncture then serves as a logical division point for M&R strategies.

In general, it was found that if the required reactivation period was less than 45 days, a common strategy could be devised. The exception to this less-than-45-day strategy would be if the reactivation period is so short that there is insufficient time for reactivation. For this case, inactive facilities must be treated as if they were active. If a reactivation time of greater than 45 days were acceptable, a common strategy could also be devised.

"Heat" and "No Heat" Alternatives

These alternatives are considered in conjunction with the decision about the reactivation period discussed above. Since the 45-day division point is due largely to the requirements of laying away boilers, it is assumed that the facility *will not* be heated if the reactivation period is greater than 45 days. If the reactivation period is less than 45 days, heating may or may not be viable. The boilers could remain active, but steam does not necessarily need to be distributed to the buildings.

The impact of "heat" versus "no heat" affects some facility components much more so than others. Primarily, the components that receive or transmit steam or condensate are the ones most affected. These components generally have very specific M&R procedural requirements directly tied to use.

It should be noted that the heating scenario used in this study assumes a 45 °F* building interior temperature during the heating season. This temperature was chosen for fuel economy. However, since maintaining that temperature can be difficult due to mechanical breakdown or other factors, and since

*U.S. standard units of measure are used in this report. A metric conversion table is printed on page 69.

temperature variations within a building can occur, it is further assumed that the plumbing systems in all buildings will be drained and weatherproofed even if the buildings are to be heated.

The decision to heat or not to heat should stem from economics. For facilities to be heated, the cost of that heat must be amortized through a reduction in the specific M&R costs that would result from not heating. As cost analysis will show (see Chapter 6), heating is not economical if the facility is properly deactivated and maintained as per the recommended guidelines.

If proper deactivation procedures are carried out, the condition of facility components will be maintained at an acceptable level of serviceability commensurate with reactivation time. Past performance of several building components at Fort Dix has revealed a tendency for buildings to deteriorate when they are not heated. While heat is a factor in some deterioration modes, it is not the only factor, or even the most critical one. The U.S. Park Service, countless individuals, and others winterize buildings in cold climates without the use of heat. Humidity control through ventilation is a much more critical parameter, and is addressed in Chapter 4.

Facility Type and Use

Logically, facility type and use should be factors in developing M&R strategies. For example, an administration building would be expected to have different M&R needs than a warehouse. Initially, it was thought that the various facility types and uses could be distinguished through the applicable category codes at Fort Dix. Realignment activities at Fort Dix encompass 28 category codes that include eight different construction types. In theory, different checklists should be developed for each. Because that approach would have resulted in large numbers of lists with considerable amounts of technical material being duplicated, the idea was dropped in favor of establishing the checklists by component type. With facility components (e.g., roofs, electrical systems) as the basis for the checklists, inspectors and other users can simply apply the appropriate component checklists to any building, thus making the product of this study easier to implement and use. As displayed in Chapters 4 and 5, each component checklist provides for four differing strategies based on the variables of deactivation period, reactivation period, and heat/no heat discussed previously. This approach also provides for a more generic application of these procedures to other installations.

Subcomponents and Materials

Although facility components make a logical basis for developing checklists, a further breakdown is required for many. This is because a facility component may consist of a variety of subcomponents, and different materials may be in place. For example, the exterior component of a building includes as subcomponents exterior cladding, windows, and doors. Each has its own M&R needs. Also, the different possible materials used in these subcomponents have different M&R needs. For example, windows with wood frames need to be painted, but vinyl-coated windows do not.

The layaway procedures developed here incorporate the subcomponents and materials found at Fort Dix as well as some of the more common types not found there. Again, this approach was taken to promote more generic application of the procedures.

Climate

Fort Dix is located in a temperate climate. Figure 1 shows the climatic region associated with New Jersey and those for the rest of the United States. The installation is subject to severe freeze-thaw cycles and high humidity. Both of these factors have been accounted for in developing the layaway procedures.

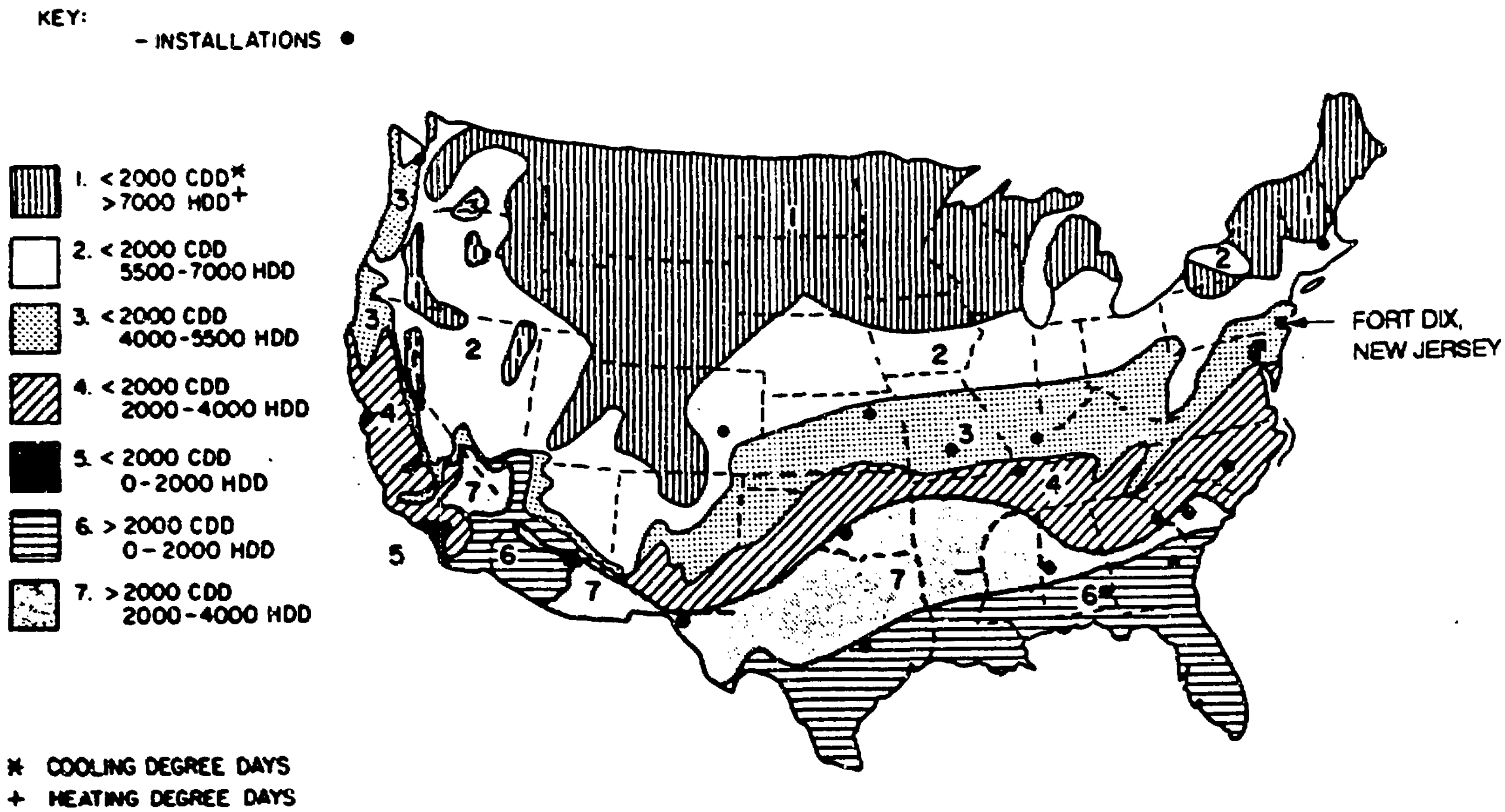

Figure 1. **U.S. climatic regions.** (Source: Hittle, D.C., R.E. O'Brien, G.S. Percivall, *Analysis of Energy Conservation Alternatives for Standard Army Buildings*, TR E-183/ADA129963 [USACERL, March 1983].)

Conceivably, in terms of climate, the procedures are applicable to other installations in the same region as Fort Dix. Application to installations outside that region should be considered with caution, however.

Maintenance Standards

A maintenance standard could be defined as the level of maintenance necessary to sustain a facility at a desired or given condition level. Each condition level would presumably enhance or detract from the mission-readiness of a facility. As Figure 2 illustrates, a large number of maintenance standards could be created for a given facility. Unfortunately, while this concept poses an interesting relationship for theorists, very little has ever been accomplished in developing practical standards that actually relate to level of condition. Condition-rating parameters are generally only in an embryonic state and then for only certain components.[3] Also, actual M&R efforts needed to sustain a given condition level have been barely researched.

This study attempts to define various levels of maintenance that would be both meaningful and practical for facility layaway. Two levels of standards resulted: "Preferred" and "Minimal." Each is described below. Each was developed using life-cycle costs and mission-driven requirements as prime criteria. A third standard, which requires doing nothing, is also discussed. These would correspond roughly to standards B, C, and D, respectively, in Figure 2.

Preferred Standard. This standard was created to reflect the professional engineering judgment of USACERL in-house and contracted professionals. The primary issues include life-safety, serviceability, and overall component integrity. The focus is on preventive maintenance and early detection and correction of deficiencies that, if left alone, will accelerate facility degradation and lead to higher reactivation costs. By implementing the Preferred standard, a facility can remain in satisfactory condition throughout a layaway period with reactivation and life cycle costs held to a minimum.

When a building to be closed is on the National Register of Historic Places or is eligible for the National Register, it is recommended that the Preferred approach be followed. The Preferred approach should provide for the appropriate stabilization of all buildings by minimizing intervention and reducing the rate of deterioration to the maximum extent possible. National Historic Landmarks or structures of exceptional significance should have layaway plans reviewed individually by cultural resource specialists.

Minimal Standard. This was developed as an absolute minimum level of effort that must be expended if the facilities are ever to be used again. Some M&R must be accomplished or else extreme deterioration will eventually result, rendering the facility unusable, perhaps even beyond a condition from which it could be economically corrected at the reactivation phase. Thus, cost factors are a premium consideration in implementing the Minimal standard. Alternate schemes for periodic M&R were incorporated to prolong component integrity without incurring the cost of a Preferred maintenance standard. Using a building exterior closure component as an example, the Preferred standard to repair a broken window would be to reglaze the affected area with new material. Alternately, the Minimal standard that requires the opening be covered with plywood and sealed with caulk. The Minimal strategy provides a necessary solution and is more economical in the short run, but results in higher costs at reactivation. This example illustrates how costs can be deferred until reactivation. The cliché, "you can pay me now or you can pay me later" is pertinent.

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[3] M.Y. Shahin, D.M. Bailey, D.E. Brotherson, *Membrane and Flashing Condition Indexes for Built Up Roofs: Vol I: Development of the Procedure*, Technical Report (TR) M-87/13/ADA190367 (USACERL, September 1987); M.Y. Shahin, D.M. Bailey, D.E. Brotherson, *Membrane and Flashing Condition Indexes for Built-Up Roofs: Vol II: Inspection and Distress Manual*, TR M-87/13/ADA190368 (USACERL, September 1987).

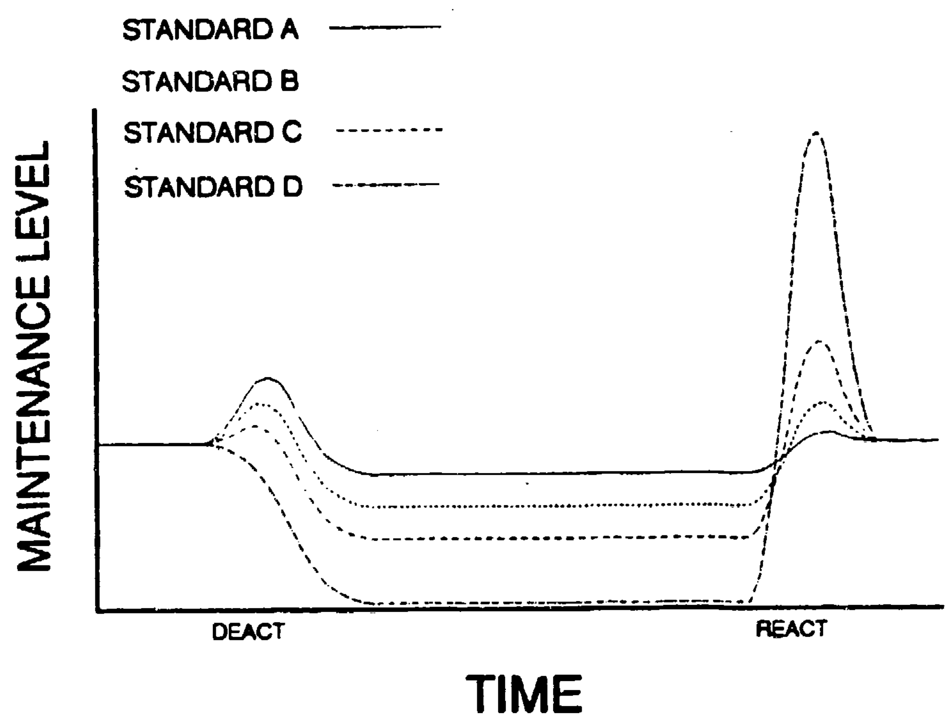

Figure 2. Maintenance standard concept.

Do-Nothing Standard. This, in reality, is no standard at all. Its name is self explanatory. As applied here, zero dollars are spent to deactivate and maintain facilities. Resources would conceivably be allocated to reactivation activities only. On the surface this would seem to be an attractive strategy: why spend money on facilities that are not in use when there is not enough for facilities that *are* in use? However, this strategy is *not* recommended. The Building Research Board (BRB) of the National Research Council states in a recent publication, "Decisions to neglect maintenance, whether made intentionally or through ignorance, violate the public trust and constitute a mismanagement of public funds. In those cases where political expediency motivates the decision, it is not too harsh to term neglect of maintenance a form of embezzlement of public funds, a wasting of the nation's assets."[4] One point is certain. There will be *no* possibility of reactivating facilites in less than 45 days when this approach is taken.

Life-Cycle Costs

Cost should always be a factor in the selection of a proper strategy. In theory, life-cycle costs could be computed for each M&R standard as applied to each component and the economic decision made. Life-cycle costs have been estimated for the maintenance standards discussed above as they pertain to each of the periods described for deactivation and reactivation times.

This topic is discussed in greater detail in Chapter 6.

[4] Building Research Board, *Committing to the Cost of Ownership - Maintenance and Repair of Public Buildings* (National Academy Press, 1990).

Decision Matrix

Figure 3 illustrates the decision matrix as described in this chapter. Figures 4 through 8 provide the matrices for buildings and the various utility systems as they pertain to Fort Dix. It should be noted that two systems do not have decision matrices: natural gas systems and boilers. For gas, safety is such an overwhelming consideration that there is but one correct approach--valves must be secured, vents made operational, and leaks repaired. Due to the unique boiler plant arrangements at Fort Dix, the only recommended approach is to do a dry layup of the boilers. The boilers are discussed in detail in Chapter 5.

Included in the decision matrix, either directly or indirectly, are all the variables previously described. To use the matrix, policy decisions must be made about the allowed reactivation time and the length of time the facilities will be laid away. These decisions, which are expected to be made outside of the engineer's domain, are a product of operations planning and can pertain to certain or all facilities.

The operational decisions related to facility layaway determine which quadrant of the matrix will be used. Each quadrant has associated with it a choice of maintenance standard. Each standard, in turn, has specified procedures (see Figure 9, for example) applicable to all facility components that are to be laid away. The choice of standard can be de[illegible] though the application of a life-cycle cost analysis. A discussion on the development of the procedures checklists follows in the next two chapters. A key to how to interpret and use the checklists is provided in Volume II, Appendix A.

REACT. PERIOD (DAYS)		DEACTIVATION PERIOD (YEARS)					
		LESS THAN 1 YEAR			GREATER THAN 1 YEAR		
		PREFER.	MINIMAL	DO NOTH	PREFER.	MINIMAL	DO NOTH
LESS THAN 45 DAYS	HEAT	LCC = C_1	LCC = C_4	LCC = C_7	LCC = C_{10}	LCC = C_{13}	LCC = C_{16}
	NO HEAT	LCC = C_2	LCC = C_5	LCC = C_8	LCC = C_{11}	LCC = C_{14}	LCC = C_{17}
GREATER THAN 45 DAYS		LCC = C_3	LCC = C_6	LCC = C_9	LCC = C_{12}	LCC = C_{15}	LCC = C_{18}

Figure 3. Decision matrix concept.

DECISION MATRIX

FACILITY: Buildings
UNITS: Equivalent Uniform Annual Cost ($/sf/year)

REACT. PERIOD (DAYS)		DEACTIVATION PERIOD (YEARS)					
		LESS THAN 1 YEAR			GREATER THAN 1 YEAR		
		PREFER.	MINIMAL	DO NOTH	PREFER.	MINIMAL	DO NOTH
LESS THAN 45 DAYS	HEAT	2.51	2.65	-	1.86	1.88	-
	NO HEAT	1.25	1.25	-	0,36	0.37	-
GREATER THAN 45 DAYS		1.25	1.25	34.84	0.40	0.45	3.70

sf = square feet

Figure 4. Decision matrix for buildings.

DECISION MATRIX

FACILITY: Underground Steam Heat Distribution System
UNITS: Equivalent Uniform Annual Cost ($/lf/year)

REACT. PERIOD (DAYS)		DEACTIVATION PERIOD (YEARS)					
		LESS THAN 1 YEAR			GREATER THAN 1 YEAR		
		PREFER.	MINIMAL	DO NOTH	PREFER.	MINIMAL	DO NOTH
LESS THAN 45 DAYS	HEAT	2.73	7.20	-	0.54	0.73	-
	NO HEAT	2.77	28.07	-	0.46	2.53	-
GREATER THAN 45 DAYS		2.77	28.07	277.97	0.46	2.53	24.52

Figure 5. Decision matrix for underground steam heat distribution system.

DECISION MATRIX

FACILITY: Electrical System
UNITS: Equivalent Uniform Annual Cost ($/year/for whole system)

REACT. PERIOD (DAYS)	DEACTIVATION PERIOD (YEARS)			
	LESS THAN 1 YEAR		GREATER THAN 1 YEAR	
	PREFERRED	MINIMUM	PREFERRED	MINIMUM
LESS THAN 45 DAYS	10700	12700	3300	5800
GREATER THAN 45 DAYS	10700	12700	3300	5800

Figure 6. Decision matrix for electrical distribution system.

DECISION MATRIX

FACILITY: Underground Storage Tanks
UNITS: Equivalent Uniform Annual Cost ($/standard tank/year)

REACT. PERIOD (DAYS)	DEACTIVATION PERIOD (YEARS)						
	LESS THAN 1 YEAR				GREATER THAN 1 YEAR		
	TEMP	PERM IN PLACE	DISPOSE & REPLACE	STORE & RE-INSTALL	PERM IN PLACE	DISPOSE & REPLACE	STORE & RE-INSTALL
LESS THAN 45 DAYS	9800	36000	-	-	4700	3500	4000
GREATER THAN 45 DAYS	9800	36000	30100	30100	4700	3500	4000

Figure 7. Decision matrix for underground storage tanks.

DECISION MATRIX

FACILITY: Sanitary System
UNITS: Equivalent Uniform Annual Cost ($/year/for whole system)

REACT. PERIOD (DAYS)	DEACTIVATION PERIOD (YEARS)			
	LESS THAN 1 YEAR		GREATER THAN 1 YEAR	
	PREFERRED	MINIMUM*	PREFERRED	MINIMUM*
LESS THAN 45 DAYS	191400	160100	62500	48900
GREATER THAN 45 DAYS	191400	160100	62500	48900

* Some capital deterioration may occur with minimal maintenance. Large capital expenditures may be required upon reactivation.

Figure 8. Decision matrix for sanitary systems.

When the chosen matrix quadrant and M&R standard are combined, an M&R strategy results. For example, buildings could be considered for long-term (greater than 1 year) layaway with a long (greater than 45 day) reactivation period. The life-cycle costs for the different maintenance standards indicate that the Preferred standard is most economical (Figure 4). Then, the appropriate procedures meeting those criteria found on the various building checklists should be used.

If economics, instead of mission, becomes the primary factor in developing an appropriate M&R strategy, the maintenance standard/decision matrix quadrant combination that yields the lowest life-cycle cost should be chosen. This M&R strategy may, however, be incompatible with mission.

General Recommendation for Army Facility Layaway Decisions

From an economics perspective, it would be most beneficial to the Army to put applicable facilities in a long-term (greater than 1 year) deactivation period and allow a reactivation period of more than 45 days. The Preferred M&R standard should also be implemented.

BRICK MASONRY UNITS	Pfr	Min	D<1yr R<45d	D>1yr R<45d	D<1yr R>45d	D>1yr R>45d
Inspect for:						
Cracks & holes	D/P/R		X	X	X	X
		D R	X		X	
		D/P/R		X		X
Chips & gouges	D/P/R		X	X		
	R				X	X
		R	X	X	X	X
Broken or missing units	D/P/R		X	X	X	X
		D R	X		X	
		D/P/R		X		X
M&R activities as required:						
Repair cracks & holes	D/P/R		X	X	X	X
		D R	X		X	
		D/P/R		X		X
Repair chips & gouges	D/P/R		X	X		
	R				X	X
		R	X	X	X	X
Replace broken or missing units	D/P/R		X	X	X	X
		D R	X		X	
		D/P/R		X		X

Figure 9. Example Inspection and M&R checklist.

3 FACILITY INSPECTION REQUIREMENTS

A facility layaway cycle consists of deactivation, periodic M&R, and reactivation phases. Each phase requires an aggressive facility inspection program no matter how long the deactivation period may be and regardless of whether the Preferred or Minimal standard is implemented. An inspection program replaces, in part, the reliance on building managers and others who report problems with active facilities.

Inspection Purposes

During Deactivation

Inspection at this phase of the facility layaway cycle serves to identify critical M&R needs that must be corrected before the facility stands vacant for any period of time. Generally, the defects to be noted for correction are those that, if left alone, would lead to worse, accelerated, or additional facility degradation. During periods of short layaway or when a short reactivation period is needed to meet mission needs, this inspection also serves to identify M&R needs that would preserve the facility in a higher state of readiness than one where the layaway period or reactivation period is relatively long. Essentially, this inspection is the first of the periodic inspections.

Periodic

These inspections serve the same purpose as the deactivation inspection, but are conducted at specified intervals while a facility is vacant.

During Reactivation

Inspection at this phase of the facility layaway cycle serves to identify defects that should be corrected to ensure that the facility attains a maximum degree of functionality, including quality of life.

Preferred Approach versus Minimal Approach

There are two differences between the Preferred and Minimal inspection approaches. First, the Preferred approach calls for inspection at more frequent intervals than the Minimal. Second, depending on the planned reactivation time of the facilty, the Preferred inspection approach would generally be more thorough than a Minimal one. For either approach there is a direct correlation between the inspection items and the required M&R activities.

Inspection Schedule

Table 1 lists the periodic inspection frequencies recommended for most facilities.

Table 1

Recommended Inspection Frequencies

Layaway Period/ Reactivation Period	Preferred Approach	Minimal Approach
< 1 year / < 45 days	Quarterly	None
< 1 year / > 45 days	Semiannual	None
> 1 year / < 45 days	Semiannual	Annual
> 1 year / > 45 days	Semiannual	Annual

The recommended Preferred frequencies are based on the philosophy that early defect detection and correction helps to sustain facility readiness and deter further degradation. The recommended Minimal frequencies are based on the philosophy that the maximum interval that any facility, system, or component should go uninspected is 1 year. The risk of rapid facility deterioration resulting from defects going undetected for more than 1 year will rise as will any associated costs for the required restoration.

Certain facility types, systems, or components require varying inspection frequencies. These result from manufacturers' recommendations on preservation, expected deterioration rates, or safety considerations. These are briefly listed below:

- Heat Distribution System. All Preferred approach inspection frequencies are quarterly and all Minimal approach inspection frequencies are semiannual for each layaway and reactivation period.

- Sanitary Systems. Varying inspection intervals pertain. Further detail is provided in Chapter 5.

- Roofs. The semiannual roof inspections consist of two separate functions, each performed annually. The first is for noting specific roof defects needing correction. The second is for identifying debris, branches, etc., for removal from the roof and rain gutters, and for clearing clogged drains and scuppers.

Inspection Effort

A team approach is desirable for building inspections, with a two-person crew being optimal. One member should be well versed in civil/architectural/structural matters and the other member well versed in electrical/mechanical matters. For roofing inspection, it is recommended that one of the inspectors be well versed in inspection procedures for ROOFER,[5] an engineered management system, (EMS) for built-up roofs. Utility system inspections also require specialized knowledge in the particular area.

[5] M.Y. Shahin, D.M. Bailey, and D.E. Brotherson, *Membrane and Flashing Condition Indexes for Built-Up Roofs, Vol I and Vol II.*

For the approximately 170 facilities scheduled for layaway at Fort Dix, with their estimated 3.6 million square feet of building area and related utilities, an estimated 1400 man-hours are needed for the Minimal inspection effort per deactivation/reactivation cycle. A Preferred inspection effort is estimated at 1800 man-hours. The difference is due to the thoroughness of the inspection. This inspection effort excludes roofing, which is estimated at 300 man-hours for both Preferred and minimal approaches per cycle.

The above estimated hours include travel time, actual inspection time, and administrative time for writing the inspection report. Any detailed planning and estimating is excluded.

Inspector Judgment

The inspection checklists found in Volume II of this report are not intended to be all-encompassing documents. Deficiencies may be found that are not on the lists.

Also, defects may be found that would normally be deferred until reactivation, but, due to their severity, require rapid attention. The inspector's judgment on the reporting of those deficiencies for corrective action must prevail.

4 BUILDING SYSTEMS

As discussed in Chapter 2, it was originally thought that separate checklists would be developed for each of the different building types and uses. Once that effort was initiated, it was found that the number of individual lists would have been quite large and that the vast majority of information provided would be duplicated from list to list. Also, since there were significant differences in material, even within the same building type, the checklists began to grow to cover the diverse materials used. If that approach were continued to completion, the final product would have been intimidating and difficult to use simply due to sheer volume.

The solution to this problem was to base the checklists on building components, with each addressing different subcomponent and material needs as necessary. The result is a streamlined product that can be applied to a large variety of buildings on a generic basis.

The reader should note that Appendix A of Volume II provides an explanation of how to interpret and use the checklists.

Building Components

Buildings were divided into logical components and subcomponents based on the criteria used in the BUILDER engineered management system currently under development at USACERL.[6] Two modifications of that division were made for this study: (1) structural and painting issues were combined into both the exterior closure and interior construction components, as required, and (2) refrigeration units, air-handling units, and mess hall equipment were addressed separately.

A discussion on the development of the specific checklists, by component, follows.

Roofing

Maintaining the roof is important for preserving the building. The major function of a roof is to protect the building from the deteriorating effects of moisture intrusion. Roof leaks can cause damage to the building structural system, exterior closure, interior construction, and furnishings. Also, to protect the roof itself, it is important to minimize roof membrane leaks. The accumulation of moisture in the roofing system increases degradation of the membrane, reduces the effectiveness of insulation, adds weight to the structural system, and causes other problems such as rotting of wood decks, corrosion of fasteners or metal decks, and loss of membrane or substrate adherence.

The checklists prepared for the roofing component (Volume II, Appendix B) were based on the inspection guidelines for ROOFER,[7] an EMS for built-up roofs (BUR). The BUR distress checklist was based on the existing distress manual.[8] The single-ply and shingle checklists were extracted from distress lists currently being developed for addition to the ROOFER system.

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[6] D.R. Uzarski, E.D. Lawson, M.Y. Shahin, D.E. Brotherson, *Development of the BUILDER Engineered Management System for Building Maintenance: Initial Decision and Concept Report*, TR M-90/19/ADA225950 (USACERL, July 1990).

[7] D.M. Bailey, D.E. Brotherson, W. Tobiasson, A. Knehans, *ROOFER: An Engineered Management System (EMS) for Bituminous Built-Up Roofs*, USACERL TR M-90/04/ADA218529 (USACERL, December 1989).

[8] M.Y. Shahin, D.M. Bailey, and D.E. Brotherson, Vol II.

The checklists contain two different severity levels. A medium-severity distress indicates noticeable deterioration. A high-severity distress indicates excessive deterioration with a high risk to the integrity of the roofing system. Only high-severity distresses are recorded during the visual inspection, except for the deactivation inspection for the Preferred approach, in which both medium- and high-severity distresses are recorded.

To alleviate water-entry problems, temporary repairs should be accomplished immediately for all recorded high-severity distresses. Permanent repair of all recorded distresses and replacement of all wet insulation should be accomplished during the next maintenance cycle except for the periodic inspection for the Minimal option, in which only temporary repairs are performed.

General repair procedures for each of the distresses are also included in the checklists. This information can be supplemented with other literature.[9]

Exterior Closure

The exterior closure component consists of the architectural and structural elements of the building envelope, plus the exterior elements immediately adjacent to the building. Its subcomponents are: exterior perimeter, exterior wall, windows and louvers, and doors.

The inspection and M&R procedures are designed to locate and identify expected deterioration of architectural, structural, and civil components associated with the building exterior and surrounding grounds. The main emphasis is on the preservation of the building envelope. The intent is to keep water, snow, animals, insects, and unauthorized personnel out of the buildings. Preferred action procedures are designed to sustain a facility at a relatively high condition level throughout its layaway period. Minimal action procedures will allow the building to degrade to a lower condition level, but allow for restoration upon reactivation. For instance, if a periodic inspection reveals cracked, broken, loose, or crumbling mortar, Preferred procedures call for affected joints to be cleaned and tuckpointed, whereas Minimal M&R only requires that affected joints are caulked. Both approaches will keep water from damaging the building and its contents, but the Preferred approach is a permanent solution and results in a higher condition level.

If breaches in the building envelope are found during the course of the routine inspections or through other sources, such as the Provost Marshall, repair should be accomplished as soon as possible. This is due to the seriousness of the problem, which will lead to accelerated deterioration if not corrected. Other items on the checklist that may be discovered can be accomplished through scheduled routine M&R.

Another emphasis is on the correction of safety defects that may result in injury to inspectors, security personnel, and others who need to work or pass through the area.

The installation of window vents, discussed later in this chapter, is necessary to assist in the preservation of the building interiors.

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[9] Carter Doyle, Wayne Dillner, Myer J. Rosenfield, *Handbook for Repairing Nonconventional Roofing Systems*, TR M-89/04/ ADA205990 (USACERL, December 1988); *Manual of Roof Maintenance and Roof Repair* (National Roofing Contractors Association [NRCA] and Asphalt Roofing Manufacturers Association [ARMA], January 1981.)

Upon reactivation of a facility, certain habitability (quality-of-life) tasks related to the exterior closure component should be accomplished. These include the washing of windows, repairing safety defects, and other items that would "spruce up" the area.

Distress such as cracking in an exterior envelope component may be symptomatic of other major problems, such as structural deterioration due to differential settlement of the foundation. When there is sufficient evidence to justify it, inspection and analysis should extend beyond the superficial symptom to determine the cause and provide a proper solution. The inspection and M&R procedures, along with the associated cost estimates (discussed in Chapter 6), do not include major repairs such as differential foundation settlement because it is impossible to predict the likelihood of such occurrences.

The exterior closure inspection and M&R checklists are found in Volume II, Appendix C.

Interior Construction

The interior construction component consists of the architectural and structural elements contained within the building envelope. Its subcomponents are walls, floors and bases, ceilings, doors, specialties, and exposed structural elements. This component does not include furniture, furnishings, and equipment.

This component includes painting and structural items located within the building interior. With the exception of structural distresses that may occur, the vast majority of interior items are directly related to habitability (quality of life). Since the buildings are not occupied, very little interior work should be accomplished periodically. The majority of the work needed to bring interior construction up to those desired levels will be accomplished upon reactivation. The longer the layaway, the more work will be required. Proper maintenance of the roof and exterior closure will minimize the need for interior repair, as will the installation of vents (discussed later in this chapter). The cleaning of building interiors will be required in all cases.

The structural and painting issues addressed for the exterior closure component are applicable to the interior construction component, as well.

The interior construction inspection and M&R checklists are found in Volume II, Appendix D.

Interior Electrical

The interior electrical component includes all electrical circuits and associated hardware required to provide safe and adequate power to operate electrical appliances and equipment within the facility. The subcomponents include transformers, circuit breakers and fuse panels for safety disconnect, all interior wiring, receptacles, electrical fixtures, motor control centers, and other electrical circuitry required to power the facility. Even though many of the circuits will be inactive during the deactivation period, proper maintenance of the electrical system is essential to ensure continued operation of essential safety, security, and fire- and flood-control equipment. Improper maintenance could result in an increased risk of fire and a significant life-safety hazard to personnel in or around the facility.

The checklists developed for the building electrical component (Volume II, Appendix E) were based on inspection and maintenance guidelines used by industry and the Army for occupied facilities. These

documents included current Army regulations,[10] Electric Power Research Institute (EPRI) reports,[11] and manufacturer maintenance handbooks.[12] Procedures were modified to compensate for extremes in temperature and humidity that may be encountered in deactivated facilities.

The Preferred deactivation and periodic maintenance procedures are designed to ensure the greatest life expectancy and reliability for the equipment. Painting, enclosure heating, lubrication, and inspection help to avoid premature failure, corrosion, or potential life-safety concerns. The Minimal approach could result in early system failure or unreliable operation due to corrosion of critical components. The Minimal procedures still recommend sealing of electrical enclosures to reduce moisture or pest damage and to avoid potential life-safety hazards.

Emergency and security systems should be provided with uninterrupted power. These systems include fire alarms, security lights, sump pumps, and the energy monitoring and control system (EMCS). Inspection should be carried out by a qualified electrician and/or adequately trained electrical technician (familiar with the specific systems) to ensure that security, fire alarm, and flood control systems are operational. The electrical technician may be required for adequate inspection of many of these systems due to their increase knowledge of the specific monitoring and alarm systems. These inspections can also identify system degradation before it becomes too costly or presents a threat to the entire facility or personnel. In addition to scheduled visits to the buildings, inspection of the electrical systems should be performed after major rains and thunderstorms. The integrity and proper operation of all critical building circuits should be checked after major disruptions of the electrical distribution system resulting from surges, outages, or repairs. If inspections during deactivation or periodic maintenance indicate failure or significant degradation of any electrical equipment which will not be repaired at the time of inspection, the equipment should be tagged with an abbreviated description of the problem. These maintenance requirements should also be recorded on a standard form or other reporting system which are maintained at the DEH office or other central location where maintenance and operations are coordinated.

If the Preferred scenario for deactivation and periodic maintenance is followed, reactivation of the electrical systems will be relatively inexpensive and quick. A qualified electrician will be required for most tasks, which include checking all circuits for corrosion or other degradation, then individually switching each load on. Inspection of any transformers and required maintenance should be performed before facility circuits are energized. Motors should be tested using a megohmmeter of high-voltage DC to determine adequate winding insulation resistance and safe operation before being brought back into service. Fuse and circuit breaker panels and any electrical components with dissimilar metals need to be inspected for corrosion. If the mission of the facility, or equipment to be used in it, differs from that which was used before deactivation, a load survey should be performed to ensure that all circuits (including breakers and transformation equipment) are well matched to the new system loads.

Plumbing

Plumbing refers to the pipes used to convey potable water from the service line throughout the building, the fixtures at which the water is used, and the building water heater or hot water storage tank. Fixtures in typical buildings (such as barracks) include shower, lavatories, bathtubs, water closets, urinals, drinking fountains, service sinks, laundry trays, and washing machines. Dining halls include additional

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[10] AR 210-17.

[11] *Guidelines: Long-Term Layup of Fossil Plants*, Final Report EPRI CS-5112 (Electric Power Research Institute [EPRI], April 1987).

[12] *Westinghouse Electrical Maintenance Hints* (Westinghouse Electric Corp., September 1976).

fixtures such as dishwashers, vegetable peelers, can washers, pot sinks, cook sinks, scullery sinks, and coffee stations. Refer to the section ***Mess Hall Equipment*** found on page 33 for further discussion.

It is assumed that the plumbing system is in good condition at the time of deactivation and that minimal deterioration will occur to the system during the deactivation period. Thus, only minimal amounts of replumbing will need to be done at reactivation (aside from replacing deteriorated washers and packing on fixtures).

The problems that needed to be addressed in the selection of layaway methods were internal corrosion/deterioration of the system, freezing of the lines, and water damage to the building. The only alternative for deactivation that will eliminate all of these problems is the complete draining and drying of the system. Flushing and/or filling of the system with a suitable corrosion-inhibiting solution was considered at the beginning of the project. However, such a procedure would require frequent monitoring to maintain correct chemical concentrations, and most corrosion inhibitors suitable for use in potable water systems are not effective unless the water is flowing.

Inspection will amount to a very small part of the plumbing layaway procedure. The vast majority of actions for plumbing revolve around draining the system at deactivation and filling it at reactivation. The procedures are basically the same for both long- and short-term layaway periods.

Development of a Minimal procedure for plumbing was difficult because the only steps that could be eliminated from the Preferred deactivation procedure were the disassembly of flushometers and shower valves at the time of deactivation. However, if the plumbing system is deactivated for 6 months or longer, the valve packing and washers in these components should be replaced at the time of reactivation because the material will age and lose its resiliency in a dry system. Therefore, for the Minimal procedure, the valves will have to be disassembled at the time of reactivation so valve packing and washers can be replaced. In the Preferred procedure, the valves would have been disassembled at the time of deactivation, so the labor cost for reactivation will be less if the Preferred approach is taken. Also, over more than 2 or 3 years, any valves left in place will tend to deteriorate more quickly than valves that are disassembled and stored in bags (mainly because a small amount of water will remain inside them). If valves are not disassembled, more of them will need to be replaced entirely at reactivation time.

Another issue in the development of the Minimal procedure for plumbing was periodic inspection and maintenance. Under the Minimal procedure, verification that the traps still contain enough propylene glycol, and replenishing it as necessary, are eliminated entirely. The consequence of this is that sewer gas may seep into the buildings during the layaway period. Sewer gas is hazardous to people and may cause accelerated deterioration of paint and metallic components.

The Do-Nothing strategy assumes total plumbing system replacement. This is reasonable because, if the plumbing system is left undrained, it is very likely that the pipes will freeze and burst during the winter. The piping system would also experience accelerated corrosion during the deactivated period.

The plumbing inspection and M&R checklists are found in Volume II, Appendix F.

Heating Systems

Building heating systems refers to all equipment within a building associated with the heating by steam generated at a central boiler plant. It does not include the steam distribution system outside the building, but does include such components as pressure-reducing stations, steam-to-hot-water converters,

flash and expansion tanks, condensate and hot water circulation pumps, condensate receivers, etc. Differences in procedures for the deactivation, periodic maintenance, and reactivation of building heating systems primarily depend on whether heat will be supplied to the building or will not be supplied to the building.

Deactivation procedures for the case in which the building will not be heated involve draining and drying the building heating system components. Under such conditions, periodic inspection and maintenance procedures are very minimal, involving essentially only walk-through inspection for signs of external sweating and corrosion of various components (and any appropriate corrective action). Where heat is provided to the buildings, a fairly rigorous preventive maintenance program is recommended. Costs of such maintenance should be easily recovered in savings in boiler fuel costs that would otherwise be spent to compensate for live steam leaks, faulty steam traps, and inoperative condensate return systems.

The heating inspection and M&R checklists are found in Volume II, Appendix G.

Air-Handler Units

Different types of air-handler units (AHU) may be present in the facilities being deactivated. They include central air handlers for providing heated and/or cooled air to the normally occupied zones, roof- and wall-mounted axial ventilation fans for bathrooms, laundry facilities and mechanical rooms, and various other forced air units to control temperature or humidity within the buildings. Most of these systems consist of some combination of an axial or centrifugal fan driven by an electric motor, dampers, filters, cooling or heating coils, pulleys, bearings, motor control center, ducting, and a control system.

Unless the building requires forced air ventilation, failure of these components during the deactivated period does not put the rest of the facility at risk of accelerated deterioration. However, the cost of complete replacement or major repair of the equipment at reactivation is much greater than the cost of appropriate preservation and periodic maintenance. Some AHUs at Fort Dix have openings to the building exterior through a roof or wall. If these openings are not properly maintained or sealed, significant building damage can occur from water or pest intrusion.

Proper preservation of unused motors includes placing them in an air-tight enclosure to prevent dirt and humidity from degrading the motor insulation. If the insulation is degraded during deactivation, extra time and effort are required to disassemble and "bake out" the motor. Some motors may have to be rewound, dipped, and baked—even replaced. Manual rotation of motors and fans should be a part of the periodic maintenance to ensure adequate lubrication and smooth rotation. If deficiencies are found, the Preferred approach is to diagnose the problem and perform the required repairs and preservation.

Since periods of high humidity will recur in the facilities, it is important that air-handler equipment be cleaned, painted, and properly lubricated to prevent high corrosion rates to bearings, shafts, and other components susceptible to oxidation. Filter media, dampers, coils, and other items that could provide a good growth medium for mold, mildew, bacteria, and other microbial contamination should be cleaned or replaced. This will help avoid indoor air quality (IAQ) problems in the facility when it is reactivated.

Where AHU systems include fire dampers, these fire-control components need to be properly maintained and periodically inspected to ensure that they can control the spread of a fire throughout the building, if one should occur while the facility is unoccupied.

For facilities where forced air ventilation will be used to help control humidity, all AHU components need to be maintained as they normally would be if the facility were fully occupied. If the equipment was only maintained when it had failed, a periodic inspection and maintenance program as outlined in the checklists (Volume II, Appendix H) should be adopted to ensure reliable operation. Since the buildings are unoccupied, failure of an AHU could go unnoticed for significant periods of time, resulting in significant moisture damage to other building components.

Reactivation procedures ensure that all rotating equipment is properly lubricated, balanced, and operating efficiently. Fan belts should be replaced as required and properly tensioned. Dampers and other openings to the outside should be cleared of debris or sealing materials. Filter media should be replaced with clean filters that are free of moisture, mold, or other potential respiratory irritants that could cause IAQ problems. All systems should be checked to ensure that they are efficiently delivering (or exhausting) the required quantity of air. If the building occupant or equipment heating/cooling load is different from that experienced before deactivation, air-handler system capacities should be checked against existing American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) standards (and others that apply) to ensure that the system can deliver adequate ventilation and conditioning to building zones.

Refrigeration Systems

The building refrigeration systems consist of space air conditioning only. They do not include refrigeration equipment for food storage or other mess hall activities. (That equipment is handled separately in the mess hall section of the building equipment.) Most of the refrigeration equipment for the facilities to be deactivated at Fort Dix consists of packaged (pad-mounted or rooftop) direct expansion (DX) units with capacities between 10 and 50 tons. These units use R-22 as the refrigerant for an electrically driven reciprocating compressor. The motors are polyphase and hermetically sealed within the compressor unit. Air-cooled condenser coils with forced draft axial fans are exclusively used on these units. There are a few built-up electrically driven reciprocating chillers and a steam driven absorption chiller with cooling towers that are affected by the post realignment. The main subcomponents for the refrigeration systems include air- and water-cooled condensers, evaporator coils, reciprocating or absorption chillers, refrigerant plumbing, cooling water loop pumps and plumbing, controls, and refrigerant.

The deactivation procedures are similar to the standard winterization that the installation performs annually to ensure that the refrigeration system sustains no major damage, including corrosion, refrigerant loss, motor degradation, or moisture ingestion. Additional care must be taken to clean, paint, or otherwise protect all exposed surfaces susceptible to corrosion. All water-side plumbing should be drained to prevent freeze or corrosion damage. Dielectric couplings should be inspected, installed, or renewed between all dissimilar metal components in the plumbing loops. Pumps and motors should be lubricated and protected from the elements.

Refrigerant should be pumped down into the receiver. Any excess refrigerant must be properly recovered and reprocessed. Refrigerants should not be purged into the atmosphere to avoid ozone depletion and violation of any standards governing the release of chlorofluorocarbons (CFCs) into the atmosphere. Receiver connections and all valves should be checked for leaks, and replaced or repaired to avoid refrigerant loss during layaway. The compressor crankcase should be filled with the normal operating oil to cover the seals and main bearings to avoid seal degradation or internal corrosion. These specially treated compressors need to be appropriately tagged to prevent operation until the excess oil has been removed. The compressor valve plate and housing should be flooded with the same oil.

The electrical service should be disconnected from all deactivated chiller systems and the main equipment switchgear should be appropriately tagged. Switchgear should be sealed and preserved using procedures similar to those outlined for the interior electrical component earlier in this chapter.

Periodic inspection of all refrigeration equipment is necessary to identify and correct any significant deterioration caused by animals, moisture, vandalism, or preservation failure. Nests and other debris should be removed. Equipment should be retreated where the preservation measures are not adequate. Any other degradation should be logged to ensure that it is considered when the post is scheduling tasks and material requirements for facility reactivation.

When the equipment is being reactivated, care must be taken to ensure that all protective coatings and coil, fan, or opening covers are removed. The electrical connections, valves, pumps, fans, and coils should be checked for corrosion and proper operation. Excess oil must be properly drained from the compressor crankcase. Any defective components, including refrigerant seals, belts, valves, etc., should be repaired or replaced before operating the units. When the refrigerant is fully recharged, all components and controls should be tested for adequate and reliable operation. Leak tests should be repeated to ensure that the compressor is maintaining its charge. Stringent requirements for avoiding CFC leaks during chiller servicing and operation will most likely be required by State or Federal law at the time of reactivation.

The refrigeration systems inspection and M&R checklists are found in Volume II, Appendix I.

Mess Hall Equipment

There are some special procedures that must be followed for dining halls because of the equipment used for the preparation, preservation, and serving of food. In addition to the plumbing fixtures that would be found in typical buildings, dining halls include several unique fixtures. These include dishwashers, vegetable peelers, can washers, pot sinks, cook sinks, scullery sinks, and coffee stations. Dining halls also include gas-fired appliances and refrigeration equipment as well as miscellaneous equipment (e.g., steam tables) that must be properly preserved. These special procedures are to be used in addition to the general guidance presented for plumbing, gas systems, and refrigeration equipment discussed elsewhere in the report. The procedures are based on the assumption that the components are in good operational condition at the time of deactivation.

The checklists (Volume II, Appendix J) were developed by examining standard Government procedures for plumbing, gas system, and refrigeration equipment layaway, by consulting with government and industry experts, and by consulting with a plumbing contractor who has extensive experience with plumbing system layaway. Additional plumbing components and refrigeration equipment unique to dining halls were identified and procedures were developed. The procedures recommend completely draining and drying the plumbing system to minimize damage from corrosion, freezing, and leakage. The gas system is deactivated by closing the gas valve to the building and relieving pressure on all gas-fired appliances. More detailed discussions can be found in the plumbing and gas distribution sections. Refrigeration equipment will be left in place. Preservation will be performed to ensure equipment integrity during the deactivation period, to prevent corrosion, and to avoid refrigerant leakage or compressor damage.

Plumbing and refrigeration issues related to mess hall equipment are the same as for plumbing and refrigeration systems, in general, which were discussed earlier in this chapter.

The checklists and guidelines given for mess hall equipment supplement the lists given for general building types to provide a complete procedure for the deactivation of dining facilities.

Ventilation Requirements

Proper building ventilation will prevent fungal growth and the occurrence of condensation. Both of these phenomenon, if present, will lead to accelerated deterioration of building interiors and, depending on the structure, structural degradation. The National Park Service has found that good air movement within a building and greater equilibrium between interior and exterior humidity levels and temperatures will preserve plaster and interior finishes.[13] Musty odors can also be eliminated.

Ventilation of confined spaces is not a new concept. Crawl-space areas of house have been ventilated for decades by vents provided for that purpose. This concept is already in use at Fort Dix in many of the buildings that are to be deactivated. For example, the crawlspace areas of the rolling pin barracks are ventilated. When in active use, the buildings are ventilated through the use of mechanical systems designed for that purpose, and through the opening and closing of windows and doors.

Expansion of the ventilation concept to the remaining portions of the buildings during layaway is proposed. Depending on the building, either mechanical or passive procedures can be used. Mechanical methods would incorporate the use of existing air-handler equipment. Passive procedures would take advantage of natural air flow.

Most of the buildings set for layaway at Fort Dix would require the use of passive ventilation. This would require the installation of louvers in windows so they would function as vents while keeping out rainwater, insects, and birds. They would also provide security on the lower floors. Simply opening windows would not provide protection from the elements, animals, or unauthorized people. Louvers could be affixed so the windows could operate normally, and could be closed in the winter if the buildings are heated. These louvers could also remain in place if the buildings were only to be reopened for short periods. If the buildings are not to be heated, the windows would remain open all year.

Appendix A provides a building ventilation plan for Fort Dix facilities.

Furniture and Bedding Issues

Since the affected buildings at Fort Dix are intended for reactivation, it is recommended that the furniture remain in place. This will eliminate transportation and storage costs. Damage from movement will also be eliminated.

Bedding (i.e., mattresses and pillows) must be given some attention, however. Care must be taken to keep bedding clean and mildew free. This will be difficult because the building ventilation scheme will allow dirt into the rooms. Also, since used bedding has an inherently high moisture level, losses due to degradation can be expected—especially over long periods of time. Ideally, it would be best if the bedding

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[13] C.E. Fisher and T.A. Vitana, "Temporary Window Vents in Unoccupied Historic Buildings," *Preservation Tech Notes* (National Park Service, U.S. Department of the Interior, 1985).

could be used at other locations during the layaway period. Upon reactivation, new or used bedding could be obtained.

If it is desired to keep the existing bedding on hand, Appendix B provides a bedding plan for Fort Dix, depending on the overall deactivation strategy. This plan takes advantage of existing dehumidification capabilities by using the mess halls for storage. Any buildings that have air conditioning or dehumidification mechanical systems would also suffice. Clearly, prior to storage, each mattress and pillow should be inspected. Those failing to meet desired standards for cleanliness, wear, or damage should be cleaned, repaired, or disposed of before storing.

Do-Nothing Facilities

Due to the relatively low value of certain facilities or the nature of their construction, it may not be worthwhile to spend money to deactivate and periodically maintain them during a layaway period. Upon reactivation, such facilities could be brought up to the desired standard or demolished and reconstructed, depending on the facility.

Decisions of this type must be made on a case-by-case basis. Appendix C provides a recommended list of Do-Nothing facilities for Fort Dix.

5 UTILITY SYSTEMS

Utility systems are an essential element of the safe and proper operation of any community, including an Army installation. They provide a variety of services to all occupied facilities. Some of these services, including electricity and water, will continue to be operational whether the unoccupied buildings are heated or not.

Unlike many of the building components, the condition of the utility systems is not always easily determined without detailed inspections or specific testing. The water, gas, steam, and parts of the electrical system are buried and susceptible to accelerated corrosion or complete failure. These could present a major safety risk if not properly monitored and maintained during any inactive period. Aboveground equipment such as electrical power poles and lines, gas line hardware, and aboveground storage tanks are exposed to the extremes of weather and could suffer catastrophic failure. If these systems were to fail they could become a major health-, fire-, or general safety risk to the immediate area. Additionally, local failure of utility systems could cause disruption of water, gas, steam, or electric service to customers on active portions of an installation as well as surrounding communities.

Deterioration rates, maintenance, and failure intervals are fairly well understood for some of these systems when normally loaded. However, inactive or lightly loaded utility systems may have degradation rates and other problems that are not well understood.

Some utility components, such as underground storage tanks, are governed by very strict requirements for their layaway or disposal. For these systems, there is no option for choosing a Minimal or Preferred scenario. Federal, State, and local laws and codes must be followed.

This chapter and the associated appendices in Volume II of the report attempt to address the issues that affect the reliability, maintainability, and associated costs for deactivation, periodic maintenance, and potential reactivation of the utility systems serving the deactivated portions of an installation. The unique aspects of Fort Dix are specifically addressed.

Steam Heating System Modeling

An extensive modeling procedure was conducted to help arrive at decisions about whether or not to heat particular buildings at Fort Dix. The decision not to heat or heat to a certain temperature has a direct bearing on what to do to the boiler plants. This discussion is detailed in Appendix D.

Steam Heating Systems

Boiler Plants

Information about procedures to be followed for boiler layup was obtained through a DIALOG literature search, review of pertinent Department of Defense (DOD) documents, review of pertinent professional societies' codes and standards, boiler manufacturers' recommendations, and discussions with individuals having industrial experience and expertise in boiler operation and maintenance. While there were considerable differences among the various sources about how long a boiler could be placed in "wet" storage (water remaining within the boiler) without damage, virtually none of the sources recommended

"wet" layup for longer than 6 months. Thus, the dry storage method described here is recommended for boiler layup at Fort Dix. Procedures for the deactivation, periodic maintenance, and reactivation of boilers and the associated auxiliary equipment are given in Volume II, Appendix K. It should be noted that the format in which these procedures appear differs from the normal matrix format used for most of the other Fort Dix components. The recommended "dry" layup method and the time requirements associated with the reactivation of a dry laid up boiler limit such application to using the Preferred approach with deactivation longer than 1 year and reactivation of longer than 45 days permitted. Therefore, the standard matrix format was considered inappropriate for illustrating the decisionmaking process for boiler plant layup.

Costs associated with the deactivation and periodic maintenance of the boilers and associated auxiliary equipment in buildings 5252, 5426, and 5881 are estimated by using proposal costs for layaway of similar boilers and associated auxiliary equipment at the Indiana Army Ammunition Plant and adding a 10 percent contingency factor. Reactivation costs are estimated by doubling the Indiana Army Ammunition Plant deactivation cost and again adding a 10 percent contingency factor. In the layaway and subsequent reactivation of electrical power boilers, it is generally assumed that reactivation costs are double deactivation costs because reactivation requires undoing all of the procedures of the deactivation process as well as inspecting and testing all equipment for proper operation. Total costs associated with deactivation, periodic maintenance, and reactivation of a boiler plant may be determined by multiplying these per-boiler costs by the number of boilers that are to be inactivated. Do-Nothing costs are based on total replacement of the boiler and associated auxiliary equipment.

Total costs associated with the deactivation of the Fort Dix heat-recovery incinerator (HRI) have been provided by the operating contractor, North American Resource Recovery Corporation. Periodic maintenance costs have been estimated as one-seventh of the maintenance costs of the larger boilers (to account for the difference in boiler size) per boiler, multiplied by four to account for all four boilers in the HRI.

Underground Heat Distribution

The steam distribution system includes the steam supply and condensate return lines that begin at the boiler plant and end at the entrance to each individual building. The manholes and building entry pits in a typical system contain components such as steam traps, drains, valves, and sump pumps.

It is important to note that certain assumptions were made in the development of the reactivation costs, particularly for the Minimal and Do-Nothing options. Reactivation costs were extremely difficult to develop because of the wide range of deactivated times possible and because a detailed system survey was not performed. Thus, the costs given represent average behavior assuming the system is in good condition when it is deactivated. Reactivation costs for the Steam On, Preferred option are assumed to be $0 because the system is not deactivated under that scenario. Reactivation costs for the Steam Off, Preferred option are assumed to involve only the standard startup procedures and minor repairs to the system. Reactivation costs for the Steam On, Minimal option are based on an assumed replacement of 2.5 percent of the system. Reactivation costs for the Steam Off, Minimal option are based on an assumed replacement of 10 percent of the system. The replacement percentage for Steam Off, Minimal is larger than the percentage for Steam On, Minimal because (1) the heat carrier pipe and casing can corrode when the system is cold and (2) problems are more difficult to detect when the system is cold because telltale signs such as steaming at vents do not occur in a cold system. These estimates of the percentage of the system to be replaced are based upon experience and expert opinion. The estimates are considered reasonable for a deactivated period of 2 to 5 years. A shorter deactivated period will result in a lower

percentage of the system to be replaced while a longer deactivated period will result in accelerated deterioration and a higher percentage of the system needing to be replace. Costs for the Do-Nothing option were based on total system replacement. Obviously, this option will not be used for short deactivated periods.

The inspection and maintenance checklists (Volume II, Appendix K) were developed by examining standard Army procedures for operation of steam distribution systems and by consulting with experts who have up to 30 years experience with Army heat distribution systems.

One of the chief concerns in the maintenance of a heat distribution system is making sure that the system remains properly drained. Accumulation of moisture in the manholes or conduit will result in accelerated deterioration and corrosion of the system. The pipe insulation will become soaked with water. If the system is operating, the insulation will be "boiled" and corrosion-induced leaks will develop in the casing and carrier pipe. If the system is shut down, the insulation will eventually rot away, and accelerated corrosion will also occur.

Another concern, particularly in the case of a system that remains in operation, is the thermal efficiency of the system. If moisture is allowed to accumulate in the system as described above, the system will lose thermal efficiency as the insulation becomes saturated and deteriorates. In addition, it is essential that steam traps and valves remain in proper operating condition to prevent thermal losses at these points.

Safety hazards such as deteriorated or corroded manhole tops and access ladders must be given immediate attention in any scenario.

The Preferred procedure was developed with the intent of providing maximum operational and thermal efficiency during the deactivated period as well as after reactivation. Deterioration of the system will be minimized if the Preferred procedure is used. If the Minimal procedure is used, operational and thermal efficiency will be reduced and deterioration of the system will proceed more rapidly.

Since very little published cost information is available on steam distribution systems, the costs given here are based on expert opinion and experience. Costs for the steam distribution system basically fit into two categories: (1) inspection and maintenance of the manhole internals and (2) inspection for, and repair of, leaks in the carrier pipe and conduit. Inspection times and costs were estimated. The number of each type of repair action needed (e.g., replace leaky valve packing, replace trap, etc.) as a percentage of the number of manholes and the total system length was estimated based on expert experience. Costs were developed for the repair actions. To determine the cost per linear foot, all of these costs were tabulated and divided by the length of the system. Costs were developed according to the assumptions given above. Appendix E provides a procedure for estimating the costs per linear foot.

The inspection and maintenance procedures for the steam distribution system are presented in a slightly different format than the rest of the checklists. The procedures are more dependent upon whether the steam is on or off than upon the various time frames given. The Heat Off scenario does not necessarily mean that the steam lines will be devoid of steam since steam may be supplied to any active buildings in the doughboy loop.* For this reason, procedures are given for Steam On and Steam Off

*The geographic area of Fort Dix that is to be deactivated.

instead of for the standard scenarios used throughout this report. The Steam On and Steam Off procedures may be used for any of the deactivation and reactivation time periods.

The inspection frequency should be quarterly for the Preferred option (all time periods) and semiannually for the Minimal option (all time periods).

The Fort Dix system does not have sump pumps or electrical service to the manholes. The Preferred option recommends the installation of sump pumps. This will significantly reduce the deterioration rate of the system because the manholes will be kept dry. The Preferred periodic inspection procedure assumes that pumps have been installed at deactivation.

The procedures presented here provide standard guidance for maintenance of the steam distribution system under Steam On and Steam Off conditions. It is critical that these procedures are followed because the heat distribution system is one of the most costly systems to replace at an installation. In addition, significant energy losses will occur if it is operated in a deteriorated (i.e., leaking or uninsulated) condition. Adherence to the given procedures, particularly the Preferred procedures, will result in efficient operation and a minimum of deterioration.

Gas Distribution System

The gas distribution system includes the pipes (mains, laterals, and service lines) and associated regulating devices (e.g., valves) that convey natural gas to the buildings. The piping is underground.

According to the information collected at Fort Dix, the gas mains are owned by Public Service of New Jersey. The Army is only responsible for the laterals and service lines. None of the latter are cathodically protected.

It is assumed that the distribution system is in good condition. It is also assumed that there is no need to install a cathodic protection system.

The checklist (Volume II, Appendix L) was developed by examining standard procedures for the operation and maintenance of gas distribution systems and by consulting with experts in the area of underground corrosion and gas distribution systems. The main concerns in deactivating the system were the elimination of safety hazards and the preservation of the system. Since the system is not cathodically protected, there is no need to conduct routine pipe-to-soil potential surveys or to perform other maintenance that would be associated with cathodic protection systems. The laterals well not be shut down; gas will be turned off at the building.

It should be noted that there are other acceptable methods for securing the gas lines at each building. It is acceptable to do one of the following:[15]

1. A mechanical device or fitting that will *prevent the flow of gas* must be installed in the service line or meter assembly.

2. The piping must be *physically disconnected* from the gas supply and the *open end sealed.*

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[15]TM 5-654, *Gas Distribution Systems Operations and Maintenance Manual* (HQDA, December 1989).

Since every task on the checklist must be performed for safety, the Preferred and Minimal alternatives are identical. There is no Do-Nothing scenario for gas service due to the safety hazard involved with leaving the gas on in unoccupied buildings.

It would be convenient to perform the periodic inspection of the gas distribution system when the buildings are inspected for exterior painting.

The only procedure for laying away the gas distribution system is to shut off the gas at the building and relieve pressure on the gas-fired units in the building as described in the checklist. For the safety reasons previously noted, there is no Do-Nothing alternative.

Petroleum Products Storage Systems

The closure of aboveground tanks is very straightforward. The tanks should have the product removed and be thoroughly cleaned if they are to be left in place. Tanks associated with boiler plants scheduled for deactivation should be left in place. The majority of the other aboveground tanks are small tanks associated with individual building heating units for World War II-era facilities scheduled for deactivation. The tanks associated with buildings scheduled for eventual reactivation should be left in place if they are in usable condition. Tanks associated with buildings scheduled for demolition should be removed as part of the demolition process.

The closure of underground storage tanks (USTs) is a much more involved issue. As underground tanks pose the danger of soil and groundwater contamination due to tank leakage, UST design, operation, and removal are governed by strict Federal and State Environmental Protection Agency (EPA) regulations.

U.S. EPA UST Program

With the passage of the 1976 Resource Conservation and Recovery Act (RCRA) and the Hazardous and Solid Waste Amendments (HSWA) in 1984, the U.S. EPA was directed to develop a UST program. This program includes rules and regulations for both existing and new USTs, including technical standards for tank design, installation and operation, and requirements for leak detection and prevention. It also includes requirements for financial responsibility and necessary corrective action for all USTs containing regulated substances. The U.S. EPA finalized these UST regulations in September 1988. These new rules impose as minimum requirements for each UST system (tank and piping) that it is equipped with a leak detection device, protected from corrosion, and has a protective device to prevent spills and overfills.

State of New Jersey UST Regulation

On 3 September 1986 the New Jersey Underground Storage of Hazardous Substances Act, was signed into law. This State law authorizes the adoption of a regulatory program for the prevention and control of unauthorized discharge of hazardous substances caused by releases from UST systems. This Act is primarily based on the Federal HSWA of 1984. On 21 December 1987 the New Jersey Department of Environmental Protection (NJDEP) adopted an Administration Code which covers UST registration requirements and fee rules. Subsequently, on 7 August 1989, the NJDEP proposed to amend Subchapters 1, 2, and 3, covering general information, registration requirements and procedures, and fees. The NJDEP repealed Subchapter 4 and proposed updated penalty provisions in Subchapter 12. The new rules in Subchapters 4 through 11 and Subchapter 15 set out the NJDEP's performance and design standards for new and existing USTs. The new rules establish minimum construction standards for all new USTs and

for upgrading existing USTs, along with establishing technical requirements for installing, closing, and removing UST systems. The new rules also establish requirements for permitting of any replacement, installation, expansion, or substantial modification of a facility, and corrective action for treating soil and groundwater contaminated by hazardous substances released from UST systems. The proposed rules were finalized in September 1990.

USACERL UST Survey Database

In 1987 USACERL developed an installation-usable UST database with dBASE III Plus® software for DOS-compatible microcomputers. This database includes tank characteristics and soil aggressiveness information corresponding to each tank location documented. In addition to providing ready access to tank information (age, capacity, substance, status, etc.), the database also provides a Leak Potential Index (LPI) in order to prioritize an installation's USTs according to potential for leakage. LPI ratings are categorized as very low, low, medium, high, and very high. Recently, USACERL updated this UST information by collecting more recent data from Army installations. These new data, complying with the 1988 EPA regulations, were entered into the database to improve data management and analysis processes.

UST Closure Procedures

A tank and its site can be closed temporarily or permanently, depending on the situation. Temporary closure procedures are restricted to cases in which the tank will not be in use for 12 months or less, unless an exception has been obtained from the regulatory authorities. Permanent closure procedures apply in all other cases. For permanent closure, the tank may either be left in place or removed. Tank removal is the preferred method unless future reactivation of the tank is anticipated. Procedures for the temporary and permanent closure of an UST are given in Volume II, Appendix M. These procedures are in accord with the recent Federal UST regulations. It should be noted that the format of the procedures given in Appendix M of Volume II differs from the normal matrix format used for most of the other Fort Dix components. This is because the regulations governing UST tank closure are of such a restrictive nature that the decision-matrix format was considered inappropriate.

When a UST is temporarily closed, leak detection and corrosion protection must continue to operate. However, leak detection is not necessary as long as the tank is empty (no more than 1 inch of residue, or less than 0.3 percent by weight of the total capacity of the UST system, remain in the system).

If a UST system is permanently closed, the tank must be emptied and cleaned by removing all liquids and accumulated sludges. The tank must also be removed from the ground or filled with inert material.

For tanks in which an explosive atmosphere exists, dry ice should be placed into the tank to replace the oxygen inside with an inert CO_2 atmosphere. When reactivating the tank, CO_2 will be displaced by the liquid filling.

The periodic inspection program for any release of residual product for tanks left in place during permanent closure is usually done through the monitoring well system, and the records are kept for 3 years. Periodic inspection as part of maintenance in temporarily closed tanks consists mainly of checking the corrosion protection system. This process is basically easy to operate, and the cost should be negligible unless there is a need for repair or replacement of the temporarily closed tank system.

Reactivation of a Tank and Compliance Cost

If a fiberglass reinforced plastic (FRP) tank is reactivated, it is necessary to check the compatibility of the tank and the new substance to be stored in the tank. Under any circumstances, it is necessary to clean the tank before reactivation. An integrity test must be performed on the tank and piping. After refilling, a vigorous inventory program should be initiated. Tank gauging and vapor, groundwater, and interstitial monitoring systems should be put in operation immediately after the tank has been returned to service.

NJDEP estimates for the cost of compliance with the Department's proposed rules for retrofitting existing tanks depend on the size of tank and the condition of the surroundings. These cost estimates per tank range from $2000 to $10,000 for monitoring systems, $5000 to $7500 for corrosion protection systems, and $1500 to $5000 for spill and overfill prevention systems.

Generic Tank Closure Cost

Since several factors affect costs within each closure category, UST closure costs can vary over a wide range. Upper and lower levels of UST closure costs are presented in Appendix F for a generic tank with a capacity of 10,000 gallons. It should be noted that the cost ranges for permanent closure are identical whether the tanks remain in place or are removed. This is because the additional costs of tank removal are offset by the savings from not needing periodic inspection after tank removal. Fieldwork connected with tank closure may be completed within a range of several hours to several days, depending on the size of the tank and other complications. Costs for UST closure-related fieldwork are also in Appendix F.

Tank Replacement and Installation Costs

Costs associated with the installation of a new UST or replacement of an existing UST depend on the type and capacity of the tank, and on the installation procedures. The range of costs for installation of various types of tanks and auxiliary equipment is given in Appendix F for a generic tank having a capacity of 10,000 gallons.

Fort Dix Issues

Specific issues concerning the USTs at Fort Dix can be found in Appendix G.

Sanitary Systems

The potable water system, wastewater system, and fire protection system are the constituents of the sanitary system.

One assumption made for these three systems was that a layaway of more than 1 year and a reactivation period of more than 45 days seems most applicable. This seems like a reasonable assumption because these systems are buried and protected under the ground and are sheltered from the elements of nature. Therefore, the 1-year deterioration rate for any of these systems would be almost immeasurably small. In addition, any serious upgrade or rehabilitation work for these systems always requires a specialized contractor with more than 45 days lead time. Consequently, most of the work recommended for these systems was based on the assumptions cited above.

Since sanitary system services must be maintained to other parts of the installation through the loop, and to any occupied building within the loop itself, no shutdown of services or closing of valves was recommended for these systems. Therefore, the Do-Nothing scenario is essentially the system's usual state of operation.

The cost estimates are the best guesses of experts in this field based on system size, configuration, and typical Army maintenance and operation practices. No capital or major project expenditures were incorporated in the cost estimates. Only estimates for manpower required to conduct normal duties for inspection, repair, and maintenance were considered.

Checklists for the sanitary system components can be found in Volume II, Appendices N through P. Appendix H of this volume discusses issues specific to Fort Dix.

Electrical Distribution System

The proposed deactivation strategy assumes that the electrical system will stay energized in the inactive portion of the post. This strategy ensures that reliable power will be maintained to all safety and security systems, including the EMCS, sump pumps, fire and security alarms, security lighting, street lighting, and any active ventilation required in selected buildings. Since Fort Dix is an open post with well traveled state roads passing through the deactivated areas, it is essential that security systems and street lighting be operational to reduce vandalism and accidents. Additional care must be taken to ensure that the electrical grid is maintained and operated such that it does not present a life-safety hazard to the general public. Routine inspection and maintenance is essential to prevent the failure of poles, conductors, transformers, and other components.

The checklist (Volume II, Appendix Q) provides suggested inspection and maintenance procedures that should be performed when installation deactivation occurs. Any deferred M&R of the electrical system should be performed at this time to ensure safe and reliable operation during the inactive period. It is essential that the inspection and required maintenance be performed by qualified electricians familiar with the distribution system. These personnel should be familiar with the system design and performance history to ensure that all elements are brought up to good operating condition. Deteriorated wood poles and structures, insulators, bushings, and connectors should all be repaired or replaced at this time to help avoid downed aerial lines. All grounding and disconnect hardware would also be tested for proper operation. The inspection and maintenance activities should conform with all applicable codes, including National Electric Code (NEC), state and local code as well as American National Standard Institute (ANSI), the National Electrical Manufacturers Association (NEMA), and the Institute of Electrical and Electronic Engineers (IEEE) standards. The primary source of information on recommended practices and frequency for maintenance should be the manufacturers literature. This information must be maintained in a central location and be properly updated. The National Fire Protection Association Code, NFPA 70B "Recommended Practice for Electrical Equipment Maintenance" should be used, where applicable, as a guide for determining frequency and practices required to perform adequate maintenance of the electrical systems. "Westinghouse Electrical Maintenance Hints" is another good source of information which should be used when planning maintenance activities.

The electrical system should not be deenergized or resized for the reduced system loads. Consequently, there is no difference between deactivation procedures for short and long deactivation periods. There is also no difference between activities required for reactivation whether longer or shorter than 45 days.

Since the system is not downsized for the reduced electrical load, it is anticipated that the failure of components will be reduced since they will be significantly oversized for the load occurring during layaway. This may result in a very poor power factor and increased utility bill penalty charges. If these charges are significant, power factor correction hardware should be evaluated to determine whether it could be cost effectively installed during the inactive period.

Most of the periodic maintenance activities in the checklist will not be required for a deactivation period of less than one year. Some preventive maintenance (PM) costs were included in the short deactivation period to cover anticipated storm and animal damage as well as normal deterioration of wood structures and other components. Although PM may not be scheduled during the first year of facility layaway, it is essential that the entire electrical system be routinely visually inspected by properly trained personnel. Since portions of the post will remain active and tied to the same grid, these routine inspections must be performed. This procedure will help avoid major component failure (e.g., downed lines or multiple pole failures) and their resulting long power interruptions and high maintenance costs.

The checklist Preferred scenario assumes that PM is performed before major component or system failure occurs. The Minimal scenario assumes that equipment is repaired or replaced after failure. The initial cost of deactivation and periodic maintenance following the Minimal scenario is lower, but the cost of totally replacing multiple wood structures or a badly damaged transformer (resulting from poor maintenance) will result in a higher life-cycle cost.

Properly trained personnel are essential to the safe and smooth operation of the electrical distribution system. They must be properly equipped and staffed to perform safe and adequate inspection, maintenance, and repair of this system to ensure reliable power is delivered to fire, life-safety, flood control, and security systems in the deactivated areas of the installation.

Building Monitoring System

An effective program for monitoring utilities (and facilities in general) is a crucial component of the overall layaway plan. Appendix I contains a discussion of potential use of the Fort Dix energy monitoring and control system (EMCS) during the layaway period.

6 ECONOMIC ANALYSIS AND BUDGETS

It was stated in Chapter 2 that cost is a variable in deciding an appropriate M&R strategy for facility layaway. Costs are divided into three categories: deactivation costs, periodic M&R costs, and reactivation costs. These costs will vary depending on the maintenance standard selected, the specific quadrant of the decision matrix that applies, and the facility component chosen. To fairly compare the various strategies, an economic analysis is required.

Economic Analysis Method

The economic analysis method used in this study for performing the life-cycle cost analysis is the Equivalent Uniform Annual Cost (EUAC) method.[16] This approach places all costs on an annual basis for a given unit of measure. Thus, the costs of different alternatives can be compared from a common perspective (Figure 10). As an example, Figure 10 shows two alternatives. Both have differing costs for deactivation, periodic M&R, and reactivation. Alternative 1 has the lowest EUAC.

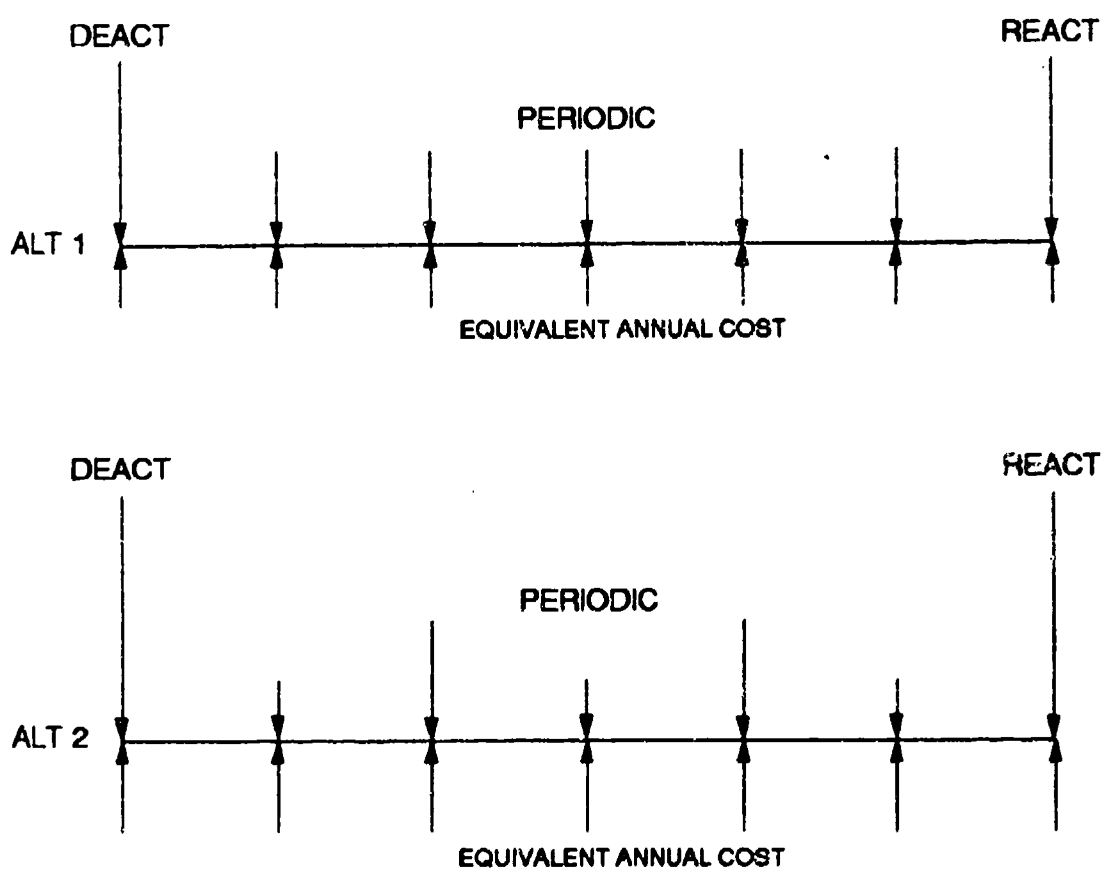

Figure 10. Comparison of alternatives through EUAC.

[16] D.D. Meredith, K.W. Wong, R.W. Woodhead, and R.H. Wortman, *Design & Planning of Engineering Systems*, Second Edition (Prentice-Hall, Inc., 1985).

Variables

Several variables are used in any given EUAC analysis. These include:

- Deactivation cost
- Periodic M&R cost
- Reactivation cost
- Interest rate
- Inflation rate
- Period under study.

Each is described briefly.

Deactivation Cost

These costs are a function of the facility component under study, the maintenance standard chosen, and the desired quadrant of the decision matrix. They involve all costs necessary to place a facility into a deactivated state at the desired condition level.

Periodic M&R Cost

These costs are also a function of the facility component under study, the maintenance standard chosen, and the desired quadrant of the decision matrix. They involve all costs necessary to maintain a facility in the desired condition level during the period of deactivation.

Reactivation Cost

These costs, too, are a function of the facility component under study, the maintenance standard chosen, and the desired quadrant of the decision matrix. They involve all costs necessary to restore a facility to the desired condition upon reactivation.

Interest Rate

This is a percentage that determines the profit derived from money lent. The value provided by TRADOC is 10 percent.

Inflation Rate

This is a percentage that reflects the increase in prices for goods and services. The value provided by TRADOC is 4.5 percent.

Period Under Study

This is the length of time, in years, for which an analysis is made. For the portion of the decision matrix representing a deactivation time of less than 1 year, 1 year was used in all of the analyses. For the portion of the decision matrix representing a deactivation time of more than 1 year, a period of 10 years was used in all analyses, as explained in Chapter 2.

M&R Costs

As previously stated, the M&R costs associated with facility layaway are categorized in terms of deactivation, periodic M&R, and reactivation costs. To perform economic analyses, an estimate of these costs is needed for each of the components under study, for each maintenance standard, and for each of the four decision matrix quadrants. For accounting purposes, these belong to the "K" account (maintenance of real property). This is illustrated in Table 2 using buildings as an example.

Determination of M&R Needs

For costs to be determined, an estimate of the expected M&R activities must first be established. This is no simple task. Two major parameters must be satisfied: (1) determining the existing baseline condition of the various facilities and (2) predicting the M&R requirements associated with the various maintenance standards under study.

The scope of this study did not include a detailed inspection of the facilities, so an accurate condition baseline could not be established. Generalized conditions, however, were determined by walk-through inspections of representative buildings and utility system components.

Table 2

Component Layaway Costs for Rolling Pin Barracks ($/GSF)

	Component	Deactivation	<1 year Period	<45 Days Reactivation	Total
	Structure	0.000	0.000	0.027	0.027
	Roofing	0.057	0.000	0.027	0.084
	Exterior const.	0.340	0.005	0.057	0.403
Minimum	Interior const.	0.027	0.000	0.257	0.283
	Elec & mech eqp.	0.011	0.000	0.052	0.063
	Plumbing	0.025	0.000	0.259	0.285
	Heating systems	0.043	0.000	0.065	0.108
	Total	0.503	0.005	0.743	1.251

The prediction of M&R needs posed a much more difficult challenge. Although USACERL is in the process of developing condition indexes for building components,[17] none is completed. If they were completed, such analyses could be made in a similar manner as they are for pavements.[18] Since such indices are not now available, USACERL combined a variety of other means to predict M&R needs and dollar resources. These are discussed below.

Maintenance Resource Prediction Model.[19] The Maintenance Resource Prediction Model (MRPM) is a USACERL-developed tool to help plan and program resources based on the anticipated M&R requirements of the actual facilities at an installation. MRPM is a multiyear cost-estimating system for determining maintenance resources. Specific installation material, labor, and equipment costs are coupled to existing facility components, materials, and inventory quantities in this model. Applicable repair tasks may be selected for which future M&R quantity and cost figures are generated.

MRPM was developed to determine requirements for active facilities and uses criteria based on expected component life in a full-use environment. These criteria are not applicable to deactivated facilities, however, so major database modifications were made so MRPM could be used in this research. Even then, its main usefulness came in aiding in the determination of dollar resources at the macro level. Unless specific information was available, the various facility components were assumed to be approximately halfway through their useful lives, based on MRPM data for average frequency of periodic maintenance and replacement.

Reference Material. An extensive literature search was conducted to determine what information is available regarding facility layaway, prediction of M&R needs, and facility component deterioration rates. The results were disappointing, but not unexpected. Although bits and pieces of information could be found, only a few references were truly helpful.[20] The Navy maintenance and operation (MO) series was particularly useful for its inspection procedures. Information provided by equipment manufacturers also proved to be very useful. All of this was primarily used to determine the kinds of M&R that would be expected.

Expert Opinion. Opinion was sought from numerous individuals known to be experts in areas germane to this study. Sources included people from academia, business, and Government service. The information gathered formed the basis for the development of maintenance standards and specific deactivation procedures. As in the use of the reference material, this helped to determine M&R needs.

Experience. People known to have been involved with facility layaway were contacted to determine lessons learned. NPS and AMC provided particularly useful information. AMC has been maintaining

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[17] Uzarski, Lawson, Shahin, and Brotherson.

[18] M.Y. Shahin and J.A. Walther, *Pavement Maintenance Management for Roads and Streets Using the PAVER System*, TR M-90/05/ADA227464 (USACERL, July 1990).

[19] E.S. Neely, R.D. Neathammer, and J.R. Stirn, *Maintenance Resource Prediction Model (MRPM): User's Manual*, Automatic Data Processing (ADP) Report P-91/12/ADA232019 (USACERL, January 1991).

[20] U.S. Army Materiel Command (AMC)-P 235-1, *Maintenance and Layaway of Government-Owned, Contractor-Operated Facilities* (AMC, July 1990); AR 210-17; Harland Bartholomew & Associates, *The Development of Standards and the Analysis of Costs Related to the Mothballing of World War II Facilities* (Harland Bartholomew & Associates, Inc., August 1989); Naval Facilities Engineering Command (NAVFAC) MO-300, *Inactivation, Caretaker Maintenance, and Reactivation of Shore Facilities* (NAVFAC, September 1980); NAVFAC MO-323, *Inspection Maintenance and Operations Manual for Naval Reserve Centers (NCR)* (NAVFAC, April 1986); Naval Facilities Engineering Command, *Preventive Maintenance Inspection - Development and Implementation Guide for Facility Managers* (NAVFAC-Chesapeake Division, September 1990); NAVFAC MO-322, *Inspection of Shore Facilities: Vol 1* (NAVFAC, July 1987).

various ammunition plants for years in a deactivated state and the NPS lays away a variety of facilities on a seasonal basis.

Various facilities at Fort Dix had been laid away on a piecemeal basis in the past. That experience also proved useful in this study.

These sources provided a "feel" for expected budget levels and also helped determine M&R needs.

Timeframes

The timeframes used for M&R prediction match those in the decision matrix, which were discussed in Chapter 2. For a deactivation period of greater than 1 year, a 10-year target was used.

Cost Determination

Once the required M&R activities were determined, the task of estimating the costs of performing those tasks remained. The estimation features of MRPM--estimating guides, supplier information, and previous project costs—all contributed to the estimation. The expected unit costs for buildings and the various utility systems are listed in Appendix J.

Generally, the M&R needs and costs for facility deactivation were fairly straightforward since many of the systems and components require specific tasks to be accomplished. The same is true for mechanical systems at reactivation. For example, for plumbing costs were developed through experience and consultation with experts. Time and material estimates were developed for each of the activities for the various fixtures in the deactivation, periodic, and reactivation procedures. The quantities of each type of fixture in a rolling pin barracks (typical building) were counted. Using the number of fixtures and the time and material estimates, total numbers of hours and materials required for deactivation, periodic, and reactivation procedures were tabulated. The number of hours was multiplied by the Fort Dix or contractor labor rates to obtain total labor costs. The material cost was added and the total was divided by the area of the building to arrive at a cost per square foot for each procedure.

Periodic M&R and the accumulation of deferred M&R that must be accomplished at reactivation was much more difficult because the estimation of quantities for M&R is rough, at best--especially since a baseline inspection was not conducted.

As discussed above, many sources were used to help determine M&R needs and costs. As a result there is a high level of confidence in the *total* costs estimated and in the *kinds* of M&R that will be expected. Lacking, however, are estimates of specific M&R needs in some future year (e.g., lineal feet of roof base flashing that will need to be repaired in 1999).

The deactivation and reactivation costs were based on the assumption that they would be accomplished with contractor labor. All periodic M&R was assumed to be accomplished with in-house labor. The estimated contract costs were determined by taking the basic Fort Dix labor rate and inflating it by an average of 55 percent to match local contractor wage rates. (This 55 percent multiplier was provided by the Philadelphia District of the Corps of Engineers.) Assuming a 40/60 split between material and labor costs, a net upward adjustment of 33 percent was made to the estimated in-house costs to estimate contractor costs.

Representative Facilities

Due to the large variety of building types and uses at Fort Dix (eight construction types and 28 category codes) the rolling pin and "T" barracks were used as the primary facilities for which M&R costs were determined. These barracks account for 48 of the 154 buildings to be laid away and 70 percent of the total building square footage in the study. Thus, these buildings were a logical choice to serve as the representative or average facility to be laid away at Fort Dix. Other building types will require more or less M&R than these barracks.

The various utility systems were studied in their entirety.

Level of Accuracy

From a total perspective, the estimated cost provide a reasonable expectation of anticipated needs. However, M&R needs and their associated costs will vary from building to building and between different portions of a given utility system. The level of accuracy is sufficient to estimate reasonable budgets. The periodic inspections are intended, in part, to determine specifically where the budgeted money should be spent.

Naturally, the further into the future the projections are made, the less accurate they become. Ten-year projections represent the limit of time for which M&R projections can be made with any semblance of accuracy.

EUAC Calculation

The economics analysis module of the USACERL MicroPAVER engineered management system[21] was used to compute the EUACs. A number of computerized packages could have been used since the model is generic; the MicroPAVER version was used for convenience. The EUAC report summaries are compiled in Appendix K.

Relationship to Decision Matrix

As was discussed in Chapter 2, EUACs are used as a basis for selecting the most cost-effective maintenance standard. For example, Figure 11 illustrates that the Preferred standard is more economical, on a life-cycle cost basis, than either the Minimal or Do-Nothing standards for the building matrix shown.

The various decision matrices in Chapter 2 display the EUACs for the different maintenance standards.

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[21] M.Y. Shahin, *MicroPAVER Concept and Development Airport Pavement Management System*, TR M-87/12/ADA187360 (USACERL, July 1987).

Budget Determination

The economic analyses provide a basis for selecting maintenance standards and overall M&R strategies. Unit costs were used to provide an equal perspective for comparison. To translate these findings into needed budget levels, some additional calculations were required.

DECISION MATRIX

FACILITY: Buildings
UNITS: Equivalent Uniform Annual Cost ($/sf/year)

REACT. PERIOD (DAYS)		DEACTIVATION PERIOD (YEARS)					
		LESS THAN 1 YEAR			GREATER THAN 1 YEAR		
		PREFER.	MINIMAL	DO NOTH	PREFER.	MINIMAL	DO NOTH
LESS THAN 45 DAYS	HEAT	2.51	2.50	-	1.86	1.88	-
	NO HEAT	1.25	1.25	-	0.40	0.43	-
GREATER THAN 45 DAYS		1.25	1.25	34.84	0.40	0.45	3.70

Figure 11. Decision matrix example with EUACs.

Method

For utilities, budgeting was a matter of simply multiplying the unit costs by the system size. The budget for buildings, however, used this same approach modified for building present replacement value (PRV). The equation used was:

$$\text{BUDGET} = \left[\frac{\frac{\text{COST}}{\text{SF}}}{\frac{\text{PRV}}{\text{SF}}} \right] \times \text{PRV}_{\text{total doughboy}} \qquad \text{[Eq 1]}$$

Rolling Pin and "T" Barracks

Present Replacement Value

The U.S. Army Engineering and Housing Support Center (USAEHSC) provided PRV information for the various facilities located at Fort Dix. Both of the barracks types have replacement values of $65/sq ft ($65.00 for rolling pin barracks and $65.20 for "T" barracks). The total PRV for all buildings planned for deactivation is $242M.

Budget Requirements

Figures 12 through 15 summarize the budget ("K" account) figures for the various no-heat M&R strategies associated with the decision matrix. Table 3 provides an example computation for one of those strategies.

The "J" account (operation of utilities) requirements associated with the layaway are very small and relate to operating the chillers and AHUs in support of the ventilation scheme discussed in Chapter 4. This amounts to an annual budget requirement of approximately $40,000. Appendix A describes this further.

Budget Relationship to PRV

The Building Research Board (BRB) of the National Research Council recently completed a study on the maintenance and repair of public buildings, including military facilities. That report concluded that an appropriate annual budget allocation for routine M&R for a substantial inventory of facilities will typically be in the range of 2 to 4 percent of the aggregate replacement value.[22] An underlying

DEACTIVATION BUDGET (IN THOUSANDS)
FACILITY: ENTIRE LAYAWAY

REACT. PERIOD (DAYS)	DEACTIVATION PERIOD (YEARS)			
	LESS THAN 1 YEAR		GREATER THAN 1 YEAR	
	PREFERRED	MINIMUM	PREFERRED	MINIMUM
LESS THAN 45 DAYS	4280	2970	3880	3040
GREATER THAN 45 DAYS	4280	2970	3880	3040

Figure 12. Deactivation budgets for differing M&R strategies.

[22] Building Research Board, *Committing to the Cost of Ownership - Maintenance and Repair of Public Buildings* (National Academy Press, 1990).

Table 3

Example Computation of a Budget for Entire Layaway

Deactivation
< 1 Year Layaway Period
< 45 Days Reactivation Notice
Minimum Maintenance
No Heat

UTILITY SYSTEMS

System	Units	Unit Cost	Quantity	Cost[+]
Boilers	Standard Boiler	$120670	8.57[*]	$1034000
Underground Heat Distribution	LF	$0.213	80000	$17000
Gas Distribution	Each Building	$44	20	$1000
Sanitary and Potable Water	System	$59850	1	$60000
Underground Storage Tanks	Standard Tank	$4490	19.83[**]	$89000
Electrical Distribution	System	$3000	1	$3000
			UTILITY TOTAL	$1204000

BUILDINGS

$$\text{BUDGET} = \left[\frac{\frac{\text{COST}}{\text{SF}}}{\frac{\text{PRV}}{\text{SF}}}\right] \times \text{PRV}_{\text{total doughboy}}$$

Rolling Pin and "T" Barracks

For: Cost/SF = $ 0.473
PRV/SF = $65.00
PRV = $242 Million

BUILDING TOTAL	$1761000
GRAND TOTAL	$2965000

[+]Rounded to nearest $1K.
[*]See discussion on p 37.
[**]See discussion on pp 106–108.

PERIODIC BUDGET (IN THOUSANDS)

FACILITY: ENTIRE LAYAWAY

REACT. PERIOD (DAYS)	DEACTIVATION PERIOD (YEARS)			
	LESS THAN 1 YEAR		GREATER THAN 1 YEAR	
	PREFERRED	MINIMUM	PREFERRED	MINIMUM
LESS THAN 45 DAYS	440	70	460	310
GREATER THAN 45 DAYS	440	70	380	260

Figure 13. Periodic M&R budgets (annual) for differing M&R strategies.

REACTIVATION BUDGET (IN THOUSANDS)

FACILITY: ENTIRE LAYAWAY

REACT. PERIOD (DAYS)	DEACTIVATION PERIOD (YEARS)			
	LESS THAN 1 YEAR		GREATER THAN 1 YEAR	
	PREFERRED	MINIMUM	PREFERRED	MINIMUM
LESS THAN 45 DAYS	3260	6940	9930	16050
GREATER THAN 45 DAYS	3260	6940	10760	17290

Figure 14. Reactivation budgets for differing M&R strategies.

TOTAL BUDGET (IN THOUSANDS)

FACILITY: ENTIRE LAYAWAY

REACT. PERIOD (DAYS)	DEACTIVATION PERIOD (YEARS)			
	LESS THAN 1 YEAR		GREATER THAN 1 YEAR	
	PREFERRED	MINIMUM	PREFERRED	MINIMUM
LESS THAN 45 DAYS	7980	9980	18410	22190
GREATER THAN 45 DAYS	7940	9980	18440	22930

Figure 15. Total M&R budgets for differing M&R strategies.

assumption was that these percentages are for active, not inactive, buildings. No study has been made that attempts to correlate M&R budgets with the replacement values for deactivated buildings. So, while the 2 to 4 percent figure is probably too high for deactivated buildings, it does represent a logical upper limit for determining and analyzing M&R budgets.

Budget Analysis

For analysis purposes, the budget scenario figures presented in Figures 12 to 15 were compared to the upper limit BRB recommendations, Army average "K" account figures, Fort Dix "K" account figures, and estimated doughboy loop "K" account figures over the recent past. These are presented visually as Figures 16 through 19. The historical data were tabulated from "Red Book" information.[23]

[23] *Facility Engineering and Housing Annual Summary of Operations: Vol III* (USAEHSC, 1985); *Facility Engineering and Housing Annual Summary of Operations: Vol III* (USAEHSC, 1987); *Facility Engineering and Housing Annual Summary of Operations: Vol III* (USAEHSC, 1988); *Facility Engineering and Housing Annual Summary of Operations: Vol I* (USAEHSC, 1989); *Facility Engineering and Housing Annual Summary of Operations: Vol III* (USAEHSC, 1989).

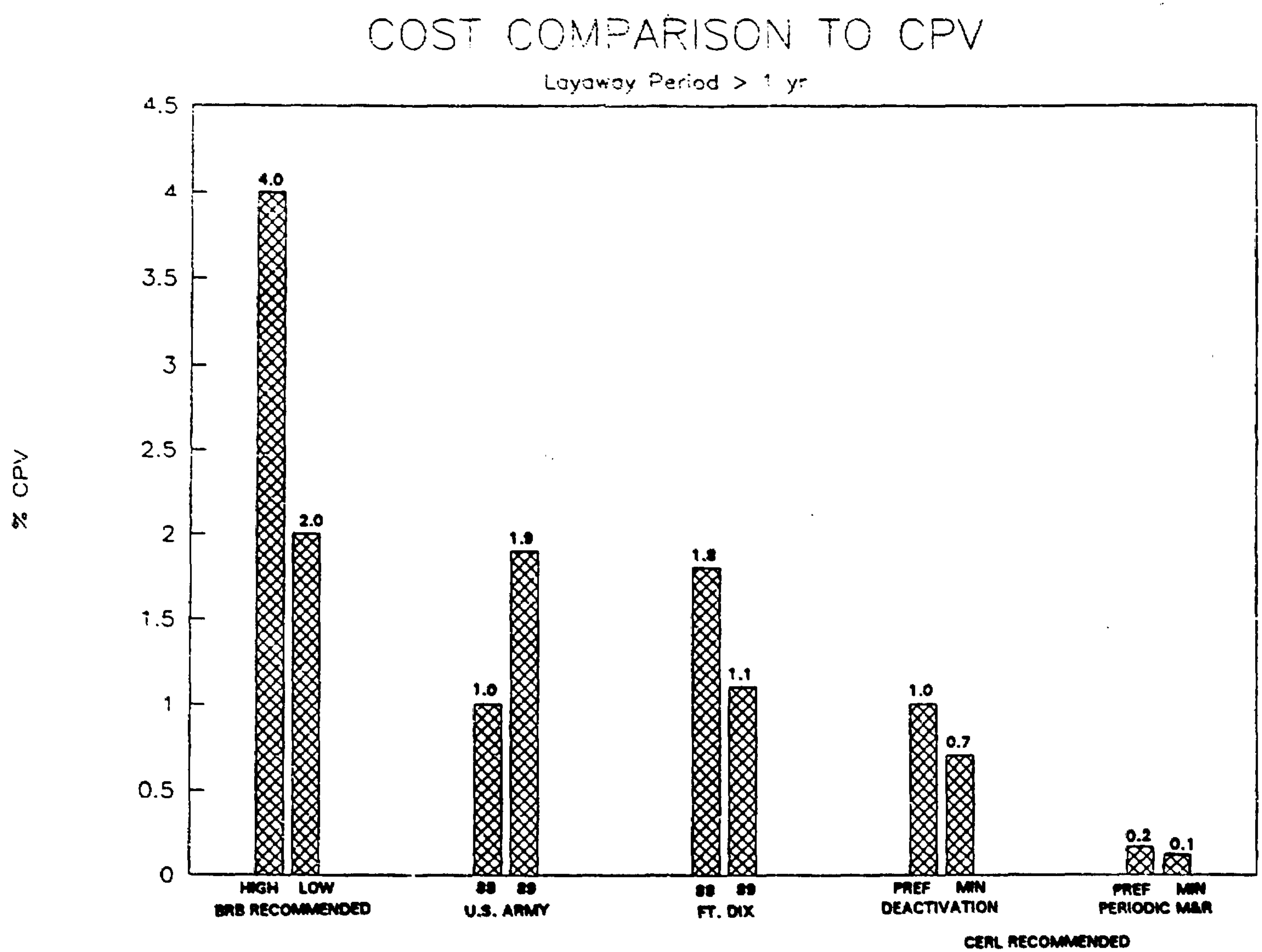

Figure 16. Budget comparisons to PRV for layaway period greater than 1 year.

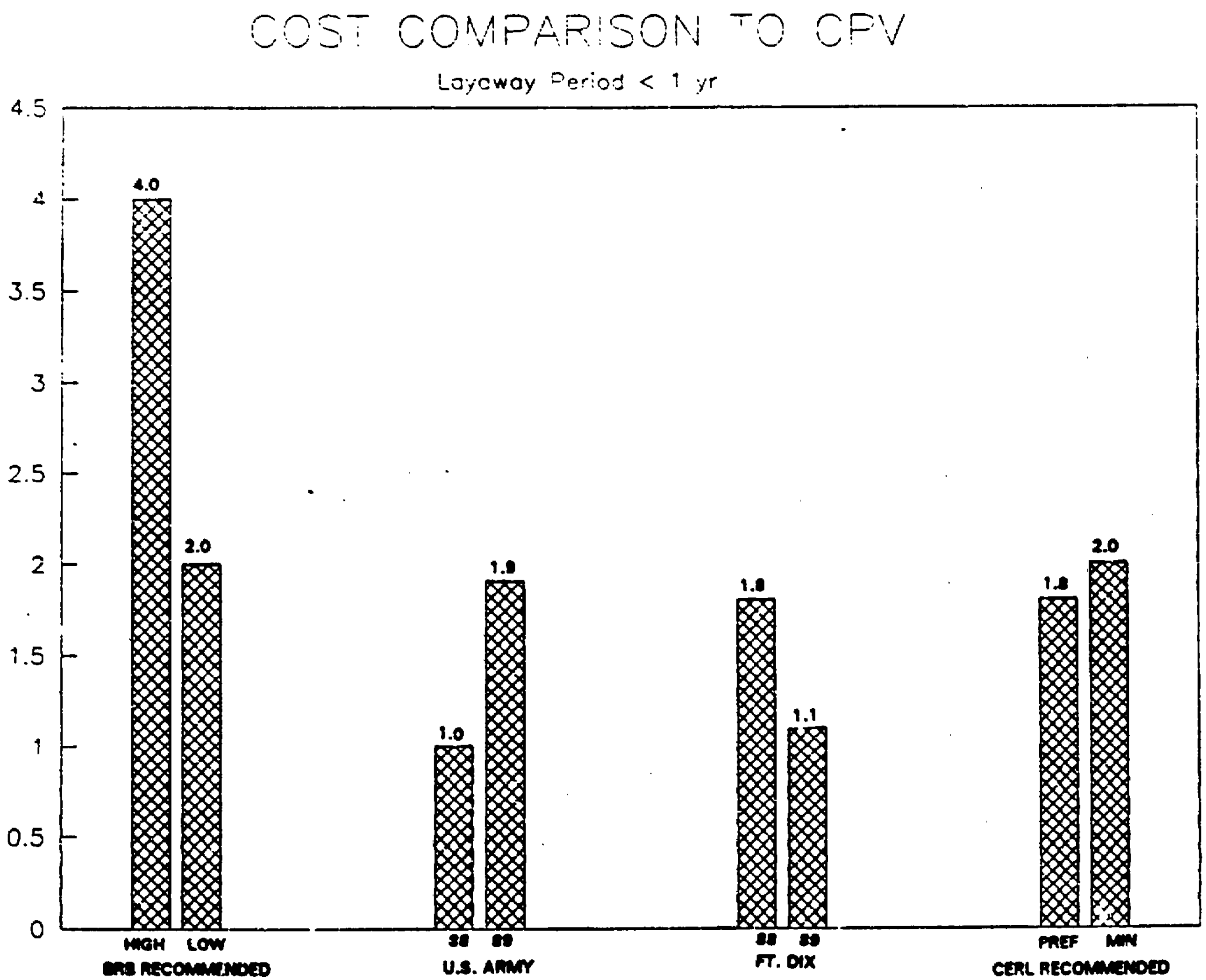

Figure 17. Budget comparisons to PRV for layaway period less than 1 year.

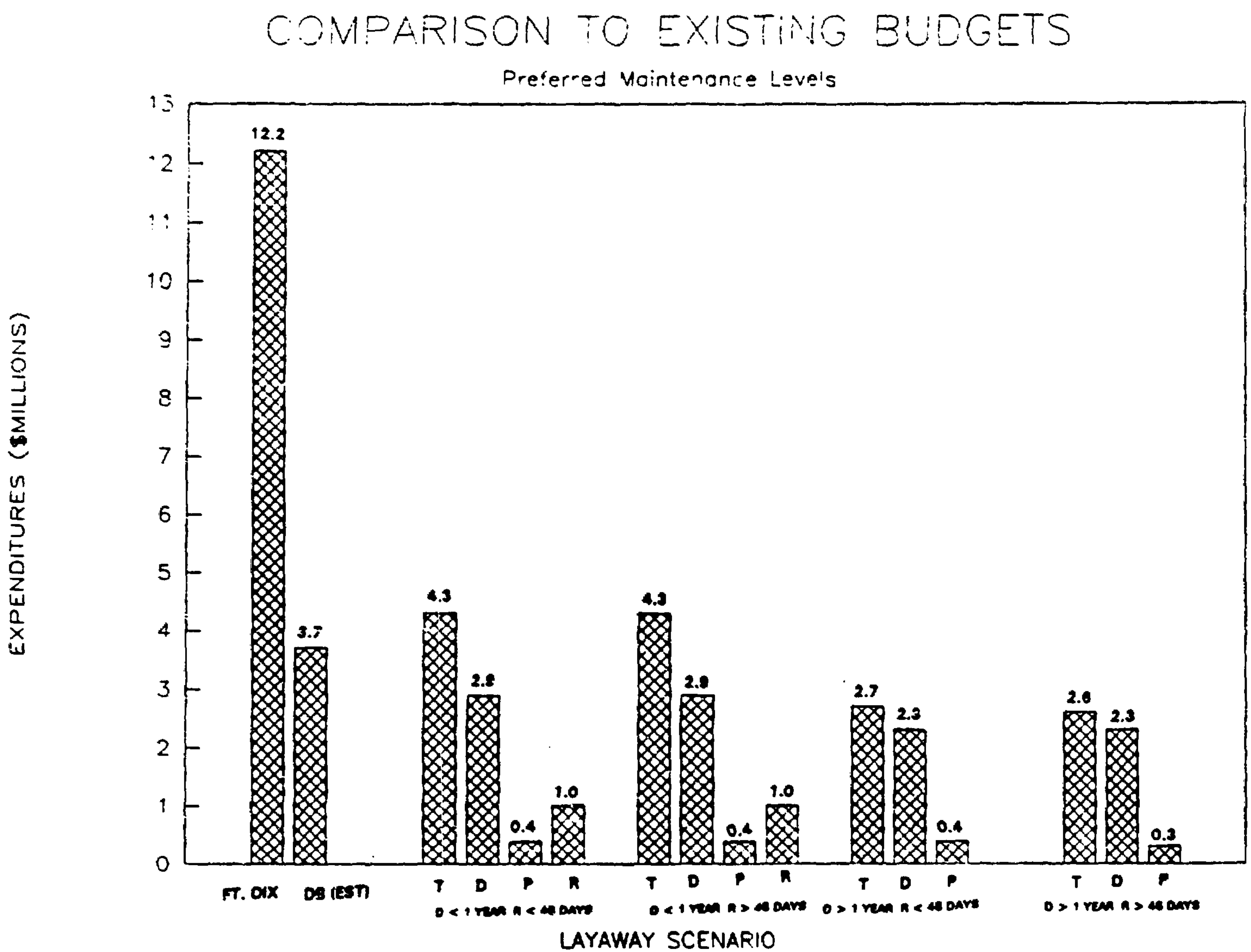

Figure 18. Comparison to existing budgets for Preferred M&R standard.

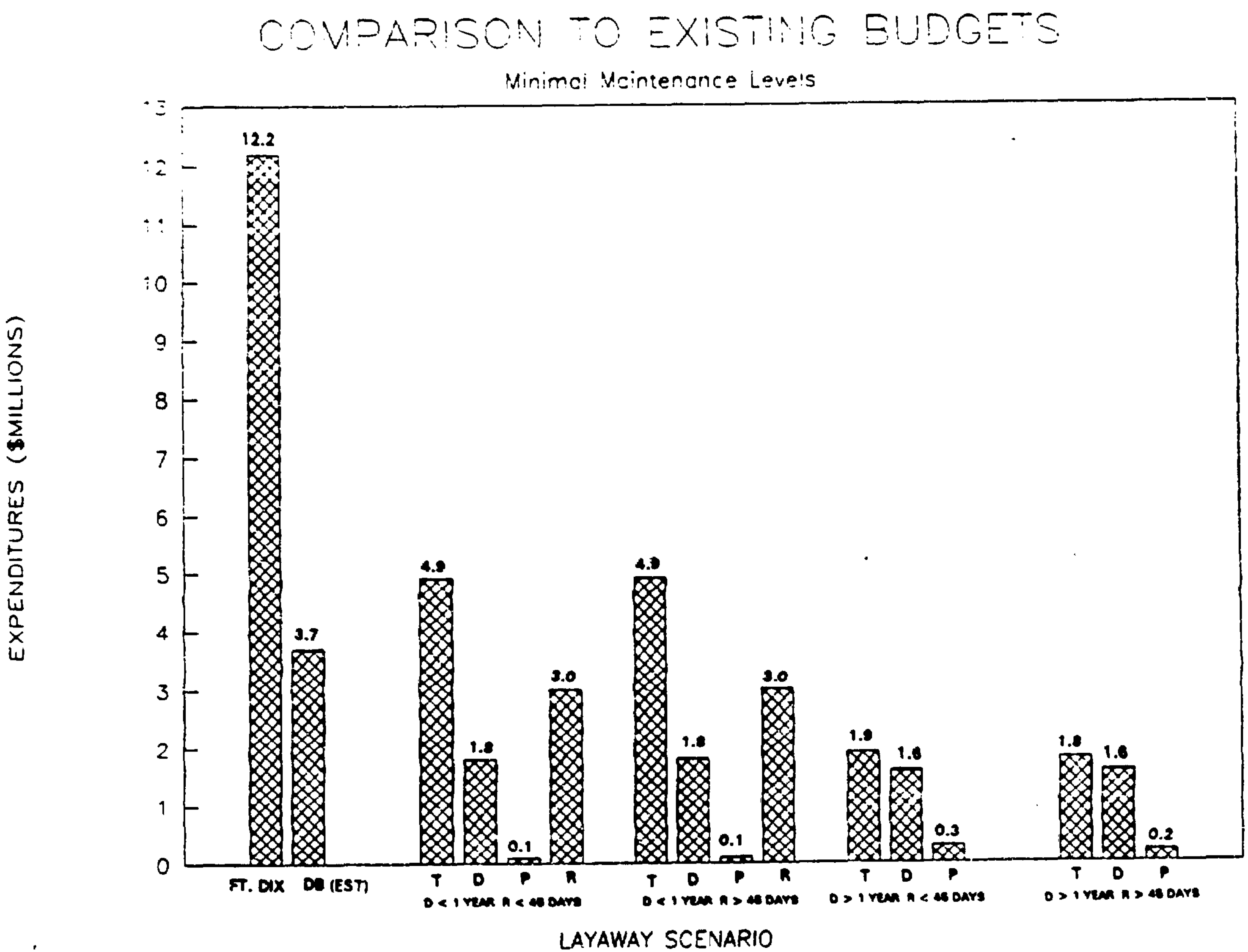

Figure 19. Comparison to existing budgets for Minimal M&R standard.

Several items of interest should be noted and understood from the above figures.

1. The existing expenditures for the doughboy loop are estimated assuming an equitable distribution of funds to PRV.

2. Both the deactivation and reactivation costs represent a combination of "one-time" items associated with actually deactivating and reactivating a facility and routine M&R. These one-time costs are above and beyond the costs normally associated with "K" account items and BRB guidelines.

3. The analysis for less than 1-year deactivation period includes deactivation, periodic, and reactivation costs (Figures 18 and 19). Those are compared to existing annual budgets. As expected, those costs are higher than existing costs.

4. The first-year annual cost for a greater-than-1-year scenario is a total of deactivation and periodic costs. This is lower than existing budgets for both Preferred and Minimal M&R standards.

5. The periodic (routine) M&R costs for the Preferred standard are below existing M&R costs. As was shown earlier, the Preferred standard is most economical in terms of life-cycle cost.

6. The periodic (routine) M&R costs for the Minimal standard are also below existing M&R costs. While use of this standard may appear attractive in terms of an annual fiscal expenditure, it is not the most economical overall.

7. The Army as a whole and Fort Dix in particular historically have been underfunding M&R in comparison to the BRB recommendations.

Prioritizing M&R Requirements

A final issue that remains is the question of what should be done if the allocated M&R budgets are less than those needed for execution of a Minimal strategy. Two possibilities exist; reduce M&R or reduce facilities.

Prioritizing Facility Components and Systems

One approach for reducing M&R costs is to prioritize the various facility components and systems. When coupled to a given budget, M&R is executed in a priority fashion until the funds run out. This approach really employs a concept of *sub*-Minimal maintenance standards. Every conceivable budget level would have a corresponding standard associated with it. The items listed in the appendices in Volume II for the Minimal standard would apply, but in prioritized fashion. Tables 4 and 5 show the recommended priorities and cumulative budget requirements for deactivation and periodic M&R respectively. Combinations of regulatory requirements, risk, safety, accelerating effects, and level of effort were all factors in priority determinations. The budgets assume that the Minimal M&R standard will be incorporated.

Table 4

Recommended Priority List for Facility Deactivation
(Assumes Minimal M&R Standard)

		Total Budget (in $K)			
Priority (1=highest)	**Item**	**D<1y R<45d**	**D<1y R>45d**	**D>1y R<45d**	**D>1y R>45d**
1	Petroleum Products Storage	89	89	297	297
2	Boiler Plants	90	90	298	298
3	Fire Protection System	103	103	311	311
4	Steam Distribution System	197	197	405	405
5	Electrical Distribution System	247	247	454	454
6	Roofing	1280	1280	1487	1487
7	Building Exterior Closure	1297	1297	1504	1504
8	Potable Water System	1300	1300	1507	1507
9	Interior Construction	1513	1513	1720	1720
10	Refrigeration Units	2785	2785	2840	2840
11	Building Electrical	2812	2812	2867	2867
12	Gas Distribution System	2826	2826	2884	2884
13	Plumbing in Buildings	2834	2834	2894	2894
14	Heating System in Buildings	2848	2848	2911	2911
15	Air-Handler Units	2852	2852	2916	2916
16	Mess Hall Equipment	2953	2953	3017	3017
17	Wastewater System	2974	2974	3038	3038

Facility Reductions

The other possibility for executing an M&R program at reduced funding levels is to reduce the number of facilities. The aim of this concept is to apply no less than the Minimal M&R standard to as many facilities as the budget will allow.

Working With Inadequate Funding

If budget levels shrink below what is necessary to at least deactivate and periodically maintain all affected facilities at the Minimal standard, it is recommended that the M&R activities to any facility *do*

not drop below the Minimal standard described in this report. The Minimal standard was developed as the lower limit to which facilities should be maintained so they can retain their value and be used again in the future. Maintaining to a level below that will invite rapid deterioration (although less than Do-Nothing), and it is quite possible that the facilities may not be able to be reactivated without major repairs or reconstruction. It would be more prudent to maintain as many facilities as possible at the Minimal level and do nothing (other than drain water lines and lock the doors) to the rest. Those Do-Nothing facilities would then await demolition or transfer to another user. This approach would be more prudent than trying to equally distribute inadequate funds and perhaps lose them all. In the absence of adequate funding, the choice of which facilities to maintain or not to maintain should be based on projected mission needs.

Table 5

Recommended Priority List for Periodic M&R (Assumes Minimal M&R Standard)

		Total Budget (in $K)			
Priority (1=highest)	Item	D<1y R<45d	D<1y R>45d	D>1y R<45d	D>1y R>45d
1	Petroleum Products Storage	4	4	0	0
2	Gas Distribution System	7	7	3	3
3	Fire Protection System	14	14	10	10
4	Plumbing in Buildings	17	17	13	13
5	Heating System in Buildings	18	18	16	16
6	Boiler Plants	18	18	181	131
7	Steam Distribution System	38	38	193	143
8	Electrical Distribution System	50	50	193	143
9	Roofing	50	50	268	218
10	Building Exterior Closure	50	50	272	222
11	Potable Water System	50	50	274	224
12	Refrigeration Units	50	50	274	224
13	Building Electrical	50	50	274	224
14	Air-Handler Units	50	50	282	232
15	Mess Hall Equipment	50	50	286	236
16	Interior Construction	50	50	287	237
17	Wastewater System	67	67	304	254

7 ENVIRONMENTAL ASPECTS AND CONSIDERATIONS

Many issues and concerns must be considered when planning or assessing the environmental impacts of facility layaway. Some of these will require further consideration and continued efforts throughout the deactivation period of the facilities. The list below highlights the major environmental aspects of deactivation and some of the problems that could occur. The topics listed below are not exclusive to Fort Dix, and are commonly found at any Army installation that undergoes deactivation.

Major Issues

Drinking Water Taste and Odor Problems

The prolonged reduction for water demand, triggered by a sharp decrease of population, will considerably enhance the potential for foul taste and odor formation within the water distribution system. This problem is addressed in more detail in the discussion of sanitary systems. In general, a distribution-flushing system (i.e., opening and flushing fire hydrants) in addition to a constant water quality monitoring program should provide ample latitude for operational personnel to control any taste and odor problems.

Underground Storage Tanks

Leaks of stored petroleum products from tanks within the deactivated area present a potential problem. One of the main guidelines for USTs calls for a thorough cleaning before deactivation. Furthermore, RCRA guidance calls for tanks 25 years or older to be tested or taken out of use by the end of 1990. Rules and regulations governing the testing procedures can be obtained from local, State, and/or Federal environmental agencies. Field personnel and contractors should be acutely aware of the procedures for product inventory and testing for active USTs. Operational problems in spell control and vapor recovery should also be emphasized.

Asbestos Construction Materials in Existing Buildings

An important environmental threat presented by some existing buildings is the friability* of asbestos construction materials with time. This friable asbestos or asbestos containing material (ACM), has been linked to several asbestos-related diseases. In order to determine whether or not ACM is present, a complete review, inspection, sampling, and written documentation of existing buildings must be done. Fort Dix recently conducted an asbestos survey, and its findings should be used as a baseline to assess the environmental hazard of asbestos now and later. It was found in this survey that approximately 80 percent of the asbestos in the area cited for deactivation has been removed. The mechanical rooms were the problem. Asbestos floor tiling in the doughboy area, which comprises the remaining asbestos problem, will be left intact. Some structures with asbestos problems are planned for removal and others are not. To ascertain that the areas not destined for asbestos removal are safe for reactivation, it is necessary to monitor those areas on an ongoing basis, making sure that the constant friability of the ACM is known. Regulatory requirements (U.S. EPA, Occupational Safety and Health Administration (OSHA), State and Local governments) for asbestos management and abatement must be heeded.

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*The tendency to crumble or disintegrate under hand pressure.

Electric Transformers Containing PCBs

Transformers in the area of Fort Dix targeted for deactivation have been checked, and there are no PCBs present. This will make the area much easier to reactivate. If transformers or other electrical system equipment is found to be filled with PCBs or PCB-contaminated oil, the EPA has specific regulations for labeling, handling, record keeping and disposal which must be followed. Compliance with all local and federal regulations regarding PCBs is mandatory.

Solid Waste/Heat Recovery Facilities

The prolonged reduction in solid waste volume on the installation can adversely affect the operation and efficiency of the HRI at Fort Dix. The HRI is currently built around four rotating kilns. At present the solid waste volumes are sufficient to operate two or three units. Long-term plans for operating this facility with reduced loads and/or out-of-post wastes should be considered during the deactivation period.

Lead- and Chromate-Based Paint

The age of the buildings at Fort Dix suggests that lead might have been added to paint used there. When lead is accumulated in the body it can cause lead poisoning, which affects the brain, nervous system, blood, and digestive system. Environmental sources of lead contamination include paint peeling from walls, window sills, ceilings, floors, and banisters as well as from soil around old buildings that have shed exterior paint over the years. A paint survey should be performed to determine the presence of lead or chromate in any of the buildings to be deactivated, and what degree of primer degradation can be allowed (based on the local EPA limits).

The possible presence of lead and chromate in some of the paint currently in place was not taken into account in estimating the M&R costs. Paints containing lead and chromate are considered hazardous waste by the EPA, and the handling and disposal of any paint residues (i.e., chips and dust removed during surface preparation or fall-off due to paint film breakdown or aging) may require special permits and safety equipment. M&R of lead- or chromate-based paint systems can cost two or three times as much as normal paint M&R. Any metal painted surfaces that were not factory primed probably use a lead or chromate primer. In addition, some factory-finished aluminum may still contain chromate.

Summary of Environmental Considerations

Certain environmental issues and concerns must be raised anytime facilities are to be laid away for possible reactivation at a future time or if they are to be disposed. Asbestos, paint, PCBs, and USTs represent common areas where problems may occur. Generally, specific testing is required to determine the extent of any suspected problem. If a problem exists, rectifying it may be very costly. This study did not call for a sampling and testing program, but the findings from existing surveys, however, have been included in the inspection and M&R checklists, costs, and budgets. However, any additional costs that may arise from further testing have not been included in the analysis.

8 SECURITY ISSUES

There are three types of threats to deactivated areas that must be considered: vandalism, vagrancy, and theft. The threat levels from vandalism are considered low to medium; the threat from vagrancy is low; and the threat from theft is considered low to medium. However, if some deactivated buildings are used to store the excess contents of other buildings, the probability of theft from those buildings may be higher.

The buildings included in this study are located in the main cantonment areas on Fort Dix. This location allows easy access for the Military Police patrols that will still be needed within the area.

Minimum Measures

The key to minimizing damage or losses is to keep unauthorized individuals out of the area. As a minimum, it is recommended that street barricades be placed on the access roads into the area to be deactivated and signs erected designating the area off limits. Police patrols should check the buildings for signs of forced entry, vandalism, or vagrancy approximately three times per shift. The ladders leading to the roof, roof hatches and openings, utility openings, and fire escapes all should be secured with an approved locking mechanism. If material and equipment are relocated and stored in other buildings, it should be stored in a neat, uniform manner so the guards may readily observe and detect any disarray at a glance. These measures are the most economical and should provide adequate protection of the deactivated area.

The costs for accomplishing these measures (less security forces) are included in the budgets discussed in Chapter 6.

Additional Measures

If the above measures prove ineffective, some additional protective measures that should be considered include, but are not limited to the following:

- Install a fence along the outside perimeter of the area that runs parallel to the highway. This may serve as a deterrent for the casual intruder.
- Install additional lighting around the buildings and the perimeter of the area. This measure is also a deterring factor and promotes better visual assessment by guards.
- Install balanced magnetic switches on the doors and windows, and motion sensors in the common areas of the buildings. These detection measures can be tied in to the existing EMCS system, and would allow immediate notification of unauthorized entry into a building.
- Entry through windows can be impeded permanently by replacing window glass with a penetration-resistant polycarbonate, or temporarily by covering the opening with plywood.
- Unauthorized vehicle access can further be denied by installing a barrier cable across entry roadways.

The costs for these additional measures are not included in the budget summaries addressed earlier.

It must be recognized that Fort Dix is an open installation and that some of the recommendations presented above may be contrary to current policies. They are nonetheless included as examples of potential solutions. It should also be recognized that there can never be 100 percent security; the level of security provided must be related to the amount of risk and loss that the installation is willing to accept.

9 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The approach taken in this study was to consolidate existing technologies into a single package of facility layaway procedures. No innovative research was attempted. In consolidating those technologies a variety of major conclusions were made and are summarized below.

1. Both the short- and long-term layaway scenarios require scheduled M&R to combat anticipated annual deterioration of the facilities' components. Facilities cannot simply be "locked up" until needed. Whether or not the facilities are in use, the forces of deterioration will continue to demand correction through maintenance and repair.

2. Application of the procedures described in this report to installations outside the Fort Dix climatic region should be considered with caution. These procedures were developed taking into account the climatic factors of central New Jersey. Deterioration modes and rates for certain distress types will differ in other climatic regions.

3. The decision to heat buildings or not should stem from economics. As the cost analysis revealed, heating is not economical if the facility is properly deactivated and maintained as per the recommended guidelines.

4. Humidity control through ventilation is a much more critical parameter than heat in minimizing building interior deterioration.

5. Life-cycle cost should always be a major factor in the selection of proper layaway strategy.

6. If the Preferred procedures are carried out, the condition of facility components will be maintained at an acceptable level of serviceability commensurate with the desired reactivation time.

7. The Minimal M&R standard provides a necessary solution and is more economical in the short run, but results in higher costs at reactivation. The Minimal standard was developed as the lower limit to which facilities should be maintained so that they can retain their value and be used again in the future. Maintaining to a level below that will invite rapid deterioration and the strong possibility exists that the facilities may not be able to be reactivated without major repairs or reconstruction.

8. Policy decisions must be made about the allowed reactivation time and the length of time that the facilities will be laid away. These decisions are expected to be made outside the engineers' domain. They will be a product of operations planning and can pertain to certain or all facilities.

9. Both the deactivation and reactivation costs represent a combination of both "one-time" items associated with actually deactivating and reactivating a facility, and routine M&R. These one-time costs are above and beyond the costs normally associated with "K" account items and the BRB guidelines.

10. The Army as a whole and Fort Dix in particular have been historically underfunding M&R as per the BRB recommendations.

11. Both the preferred and minimal periodic budget costs are below those recommended for active buildings.

Recommendations

The following recommendations are made concerning facility layaway:

1. Installation personnel should follow the procedures as described.

2. The Preferred M&R standard should be used because it results in the lowest life-cycle cost to the U.S. Army.

3. The Do-Nothing approach should *not* be pursued with any facility that is to be reactivated.

4. If operations guidance is lacking, all facilities should be placed in long-term layaway with a long reactivation period, because this is the most economical way to handle an underdefined layaway scenario.

5. If budget levels shrink below what is necessary to at least deactivate and periodically maintain facilities to the Minimal maintenance standard, it is recommended that the M&R activities for any facility *not* drop below the Minimal standard provided in this report. It would be better to maintain as many facilities as possible at the Minimal level and let the others stand idle to await demolition or transfer than to try to equally distribute inadequate funds and risk losing all facilities. The choice of which facilities should be maintained and which should not must be made based on projected mission needs.

6. A complete condition and M&R strategy evaluation should be planned for the late 1990s to map out the facility M&R requirements for the next decade.

7. The initiation of a periodic facility inspection program as described in Chapter 3 should commence as soon as possible.

8. The procedures described in this report should be field-validated through a scientifically designed and administered field test. This test should consist of inspection and monitoring of facility components to determine modes and rates of deterioration. The periodic M&R and required reactivation needs should be compared with those expected and the planned budgets. This test should be conducted at Fort Dix and other appropriate sites. It would constitute a portion of a Phase II effort to quantify and generalize the results of this research.

9. A Phase II research effort should also include study of facilities and climatic regimes different from those at Fort Dix. These results should then be consolidated with the findings of this study to compile a more universally applicable methodology for facility layaway.

10. Publish the findings of this entire body of research as a Department of the Army technical manual.

11. The checklist procedure should be computerized incorporating a database manager. This would allow users the capability of extracting only the germane portions (M&R standard, layaway period, reactivation period, system, and component) of Volume II that are specifically needed at a particular time. This would make the Volume II checklists easier to use.

12. The decision matrix should be computerized to facilitate universal application. Through computerization, the value of each variable can be adjusted easily and analyzed through an economic analysis model.

METRIC CONVERSION TABLE

1 in.	=	25.4 mm
1 ft.	=	0.305 m
1 psi	=	6.89 kPa
1 gal	=	3.78 L
°F	=	(°C + 17.78) x 1.8

CITED REFERENCES

Army Regulation (AR) 210-17, *Inactivation of Installations* (Headquarters, Department of the Army [HQDA], January 1967).

Bailey, D.M., D.E. Brotherson, W. Tobiasson, and A. Knehans, *ROOFER: An Engineered Management System (EMS) for Bituminous Built-Up Roofs*, USACERL Technical Report (TR) M-90/04/ADA218529 (U.S. Army Construction Engineering Research Laboratory [USACERL], December 1989).

Base Realignments and Closures: Report of the Defense Secretary's Commission (U.S. Department of Defense [DOD], December 1988).

Building Research Board, *Committing to the Cost of Ownership—Maintenance and Repair of Public Buildings* (National Academy Press, 1990).

The Development of Standards and the Analysis of Costs Related to the Mothballing of World War II Facilities (Harland Bartholomew & Associates, Inc., August 1989).

Doyle, Carter, Wayne Dillner, and Myer J. Rosenfield, *Handbook for Repairing Nonconventional Roofing Systems*, TR M-89/04/ADA205990 (USACERL, December 1988).

Facility Engineering and Housing Annual Summary of Operations: Vol III (U.S. Army Engineering and Housing Support Center [USAEHSC], 1985).

Facility Engineering and Housing Annual Summary of Operations: Vol III (USAEHSC, 1987).

Facility Engineering and Housing Annual Summary of Operations: Vol III (USAEHSC, 1988).

Facility Engineering and Housing Annual Summary of Operations: Vol I (USAEHSC, 1985).

Facility Engineering and Housing Annual Summary of Operations: Vol III (USAEHSC, 1989).

Fisher, C.E., and T.A. Vitana, "Temporary Window Vents in Unoccupied Historic Buildings," *Preservation Tech Notes* (U.S. Department of the Interior, National Park Service, 1985).

Guidelines: Long-Term Layup of Fossil Plants, Final Report EPRI CS-5112 (Electric Power Research Institute, April 1987).

Hittle, D.C., R.E. O'Brien, and G.S. Percivall, *Analysis of Energy Conservation Alternatives for Standard Army Buildings*, TR E-183/ADA129963 (USACERL, March 1983).

Manual of Roof Maintenance and Roof Repair (National Roofing Contractors Association [NRCA] and Asphalt Roofing Manufacturers Association [ARMA], January 1981).

Meredith, D.D., K.W. Wong, R.W. Woodhead, and R.H. Wortman, *Design & Planning of Engineering Systems*, 2nd edition (Prentice-Hall, Inc., 1985).

NAVFAC Maintenance and Operation Manual (MO)-300, *Inactivation, Caretaker Maintenance, and Reactivation of Shore Facilities* (NAVFAC, September 1980).

NAVFAC MO-322, *Inspection of Shore Facilities: Vol 1* (NAVFAC, July 1987).

NAVFAC MO-323, *Inspection Maintenance and Operations Manual for Naval Reserve Centers (NCR)* (NAVFAC, April 1986).

Neely, E.S., R.D. Neathammer, and J.R. Stirn, *Maintenance Resource Prediction Model (MRPM): User's Manual*, Automatic Data Processing (ADP) Report P-91/12/ADA232019 (USACERL, January 1991).

Preventive Maintenance Inspection-Development and Implementation Guide for Facility Managers (Naval Facilities Engineering Command [NAVFAC] - Chesapeake Division, September 1990).

Shahin, M.Y., D.M. Bailey, and D.E. Brotherson, *Membrane and Flashing Condition Indexes for Built-Up Roofs, Vol I: Development of the Procedure*, TR M-87/13/ADA190367 (USACERL, September 1987).

Shahin, M.Y., D.M. Bailey, and D.E. Brotherson, *Membrane and Flashing Condition Indexes for Built-Up Roofs: Vol II: Inspection and Distress Manual*, TR M-87/13/ADA190368 (USACERL, September 1987).

Shahin, M.Y., and J.A. Walther, *Pavement Maintenance Management for Roads and Streets Using the PAVER System*, TR M-90/05/ADA227464 (USACERL, July 1990).

Shahin, M.Y., *MicroPAVER Concept and Development Airport Pavement Management System*, TR M-87/12/ADA187360 (USACERL, July 1987).

Sliwinski, B.J. and E. Elischer, *Analysis of Facilities' Energy Use Patterns*, USACERL TR E-186/ADA132527 (USACERL, August 1983).

TM 5-654, *Gas Distribution Systems Operations and Maintenance Manual* (HQDA, December 1989).

U.S. Army Materiel Command (AMC)-P 235-1, *Maintenance and Layaway of Government-Owned, Contractor-Operated Facilities* (AMC, July 1990).

Uzarski, D.R., E.D. Lawson, M.Y. Shahin, and D.E. Brotherson, *Development of the BUILDER Engineered Management System for Building Maintenance: Initial Decision and Concept Report*, TR M-90/19/ADA225950 (USACERL, July 1990).

Westinghouse Electrical Maintenance Hints (Westinghouse Electric Corp., September 1976).

UNCITED REFERENCES

American National Standard Institute (ANSI)/IEEE Std 242-1986, 2nd edition, *IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems* (ANSI, 1986).

ANSI/IEEE Std 493-1980, *IEEE Recommended Practice for Design of Reliable Industrial and Commercial Power Systems* (ANSI, 1980).

IE Information Notice No. 85-86: *Inadequate Environmental Control for Components and Systems in Extended Storage or Layup* (U.S. Nuclear Regulatory Commission Office of Inspection and Enforcement, 15 July 1985).

Liska, R.W., *Means Facilities Maintenance Standards* (R.S. Means Company, Inc., 1988).

Meier, H.W., *Construction Specifications Handbook*, 3rd edition (Prentice-Hall Inc., 1983).

Preservation, Storage and Preventive Maintenance of Seabrook II Equipment Materials & Structures, ASP-6, Revision 2 (New Hampshire Yankee/Seabrook Project, May 1988).

Rosen, H.J., *Construction Specification Writing, Principles and Procedures*, 2nd edition (John Wiley & Sons, 1981).

Technical Specification SP-1302-12-201, Revision 3, *Lay-up of Mechanical Equipment For Planned Outages* (GPU Nuclear Corporation, October 1985).

The Development of Standards and the Analysis of Costs Related to the Mothballing of World War II Facilities, Study Preliminary Submittal (Harland Bartholomew & Associates, Inc., August 1989).

APPENDIX A:

FORT DIX BUILDING VENTILATION PLAN

This ventilation plan is applicable for both the Minimal and Preferred maintenance standards. The procedures offered below represent a minimum approach for ventilation. More elaborate procedures could be incorporated, but would not be as economical.

Explanation of Procedures

Each building type listed uses one of two distinct ventilation procedures:

- Mechanical ventilation
- Passive ventilation

Mechanical Ventilation

This approach uses the existing mechanical systems with some modifications to the control strategy. The AHU fans will be run to minimize the relative humidity within the building. The present controls for determining fan operation, based on interior temperature or time of day, should be replaced with components that sense and compare interior and outside relative humidity. The control system will ensure that the fan does not deliver outside air that is above 70 percent RH. The control strategy will also ensure that the AHU is providing fresh air to the building if the inside relative humidity is above 80 percent and the outside air is below 70 percent. For proper operation of this strategy, it is very important that the indoor humidistat be located in a space that tends to have the highest humidity within the building. This will help ensure that moisture related damage to the building and its contents is minimized. Even if the outside air is above the acceptable level for delivery to the building, it may be necessary to run the AHU to mix air within the building and to help eliminate any zones with unacceptably high humidity. Costs for humidistats and annual electrical energy requirements for fan operation are provided in the listing for each building type. It is imperative that the humidistats be recalibrated at least semiannually to ensure that the system operates properly.

Mechanical ventilation is necessary when there is insufficient window area to permit installation of louvers or where the building layout would not allow for adequate natural air flow removal of moisture from critical spaces. The exception is mess halls, which is discussed below.

Passive Ventilation

This approach requires the installation of louvers in strategic locations throughout the building. The dimensions of the existing window frame openings must be field-verified before order, manufacture, and installation of the louvers.

Louvers are to placed on each floor on opposite sides of the building. All interior room doors are to be wedged in a fully opened position. Where applicable, exit stairwell fire doors are to remain in a closed position. To calculate the number of louvers required per building, the following data were used:

- Open plan buildings—1:500 ratio (i.e., 1 sq ft of louver to 500 sq ft building)

- Closed plan buildings—1:100 ratio.

Note: If the buildings are heated during deactivation, action must be taken to close windows that have louvers for the duration of the heating season.

MECHANICAL VENTILATION PROCEDURES

Building Type: MESS HALLS

Building numbers included: (16 total)

5601, 5610, 5640, 5650
5701, 5710, 5740, 5750
5801, 5810, 5840, 5850
5904, 5905, 5985, 5986

Ventilation Scheme:

- Run chiller in cooling season only and run air handler units all year as appropriate to minimize humidity
- Install two humidistats per building
- Approx. cost of humidistats per building type = $ 32,000
- Approx. cost of annual utility operations = $ 24,000

Note: The above alternative should be used only if mattresses will be stored in the mess halls. If mattresses are not to be stored in the mess halls, different procedures apply. See note for mess halls in "Passive Ventilation Procedures."

Building Type: EXCHANGE BRANCHES

Building numbers included: (4 total)

5632, 5732, 5832, 5956

Ventilation Scheme:

- Run air handler units all year as appropriate to minimize humidity
- Install two humidistats per building
- Approx. cost of humidistats per building type = $ 8,000
- Approx. cost of annual utility operations = $ 8,000

Building Type: <u>RECEPTION FACILITY</u>

Building number: 5656

Ventilation Scheme:

- Run air handler units all year as appropriate to minimize humidity
- Install two humidistats
- Approx. cost of humidistats = $ 2,000
- Approx. cost of annual utility operations = $ 8,000

Building Type: <u>THEATER BUILDING</u>

Building number: 5755

Ventilation Scheme:

- Run air handler units all year as appropriate to minimize humidity
- Install two humidistats
- Approx. cost of humidistats = $ 2,000
- Approx. cost of annual utility operations = $ 9,000

PASSIVE VENTILATION PROCEDURES

Building Type: <u>ROLLING PIN BARRACKS</u>

Building numbers included: (43 total)

5602, 5603, 5606, 5611, 5612, 5641,
5642, 5645, 5646, 5651, 5652
5702, 5703, 5706, 5707, 5711, 5712,
5741, 5742, 5745, 5751, 5752
5802, 5803, 5806, 5807, 5811, 5812,
5841, 5842, 5845, 5851, 5852
5910, 5911, 5912, 5913, 5951, 5952,
5989, 5990, 5991, 5992

Ventilation Scheme:

- Number of louvers per building = 66
- Number of louvers per floor = 22
- Total number per building type = 2,838
- Approx. cost of louvers per building = $8,250
- Approx. total cost per building type = $355,000

Building Type: <u>T-BARRACKS</u>

Building numbers included: (5 total)

Building numbers not specified in study.

Ventilation Scheme:

• Number of louvers per building	=	66
• Number of louvers per floor	=	20
• Number of louvers per mess hall	=	6
• Total number per building type	=	330
• Approx. cost of louvers per building	=	$8,250
• Approx. total cost per building type	=	$ 41,000

Building Type: <u>MESS HALLS</u>

Building numbers included: (16 total)

5601, 5610, 5640, 5650
5701, 5710, 5740, 5750
5801, 5810, 5840, 5850
5904, 5905, 5985, 5986

Ventilation Scheme:

• Number of louvers per building	=	4
• Total number per building type	=	64
• Approx. cost of louvers per building	=	$500
• Approx. total cost per building type	=	$8,000

Note: This procedure should only be used if mattresses are not stored in the mess halls.

Building Type: <u>ADMINISTRATION & SUPPLY BUILDINGS</u>

Building numbers included: (11 total)

5604, 5643, 5653
5704
5804, 5813, 5853
5917, 5954, 5958, 5996

Ventilation Scheme:

• Number of louvers per building	=	4
• Total number per building type	=	44

- Approx. cost of louvers per building = $500
- Approx. total cost per building type = $ 6,000

Building Type: <u>UNIT CHAPELS</u>

Building numbers included: (4 total)

5635, 5735, 5835, 5950

Ventilation Scheme:

- Number of louvers per building = 6
- Total number per building type = 24
- Approx. cost of louvers per building = $1,000
- Approx. total cost per building type = $ 4,000

Note: Two louvers shall be placed in the sanctuary and the remaining four placed in the administrative wing.

Building Type: <u>CLINIC WITH BEDS</u>

Building numbers included: (4 total)

5633, 5733, 5833, 5955

Ventilation Scheme:

- Number of louvers per building = 6
- Total number per building type = 24
- Approx. cost of louvers per building = $750
- Approx. total cost per building type = $ 3,000

Building Type: <u>CLASSROOM & BN HEADQUARTERS</u>

Building numbers included: (12 total)

5605, 5644, 5654
5705, 5744, 5754
5805, 5854
5918, 5919, 5994, 5995

Ventilation Scheme:

- Number of louvers per building = 2
- Total number per building type = 24

• Approx. cost of louvers per building	=	$250
• Approx. total cost per building type	=	$ 3,000

Building Type: <u>REGIMENTAL HEADQUARTERS BUILDINGS</u>

Building numbers included: (4 total)

5634, 5734, 5834, 5957

Ventilation Scheme:

• Number of louvers per building	=	24
• Number of louvers per floor	=	8
• Total number per building type	=	96
• Approx. cost of louvers per building	=	$3,000
• Approx. total cost per building type	=	$ 12,000

Building Type: <u>GENERAL INSTRUCTION BUILDINGS</u>

Building numbers included: (10 total)

5748, 6504, 6520, 6621, 6622,
6741, 6749, 6884, 6896, 6898

Ventilation Scheme:

• Approx. number of louvers per building	=	5
• Total number per building type	=	50
• Approx. cost of louvers per building	(see note)	
• Approx. total cost per building type	=	$ 6,000

Note: The 10 buildings of this building type have varying square footages. The rule of thumb to follow is one louver (2 ft x 3 ft) for every 600 sq ft of building.

Building Type: <u>APPLIED INSTRUCTION BUILDINGS</u>

Building numbers included: (10 total)

5720, 5924, 6510, 6523, 6555,
6574, 6735, 6736, 6737, 6738

Ventilation Scheme:

• Number of louvers (5720 & 5924) 2/bldg.	=	4
• Number of louvers (6510 - 6738) 2/bldg.	=	16

- Total number per building type = 20
- Approx. total cost per building type = $ 3,000

Building Type: <u>BN CLASSROOM</u>

Building number: 5920

Ventilation Scheme:

- Number of louvers = 4
- Approx. cost per building = $ 1,000

Building Type: <u>VEHICLE MAINTENANCE SHOPS</u>

Building numbers included: (4 total)

5880, 5921, 5922, 5923

Ventilation Scheme:

- Number of louvers per building = 2
- Total number per building type = 8
- Approx. cost of louvers per building = $500
- Approx. total cost per building type = $ 2,000

Building Type: <u>ELECTRONIC EQUIPMENT BUILDING</u>

Building number: 6885

Ventilation Scheme:

- Number of louvers = 4
- Approx. cost = $ 1,000

Building Type: <u>GENERAL STOREHOUSE BUILDINGS</u>

Building numbers included: (2 total)

6521, 6704

Ventilation Scheme:

- Number of louvers per building = 2
- Total number per building type = 4

• Approx. cost of louvers per building	=	$500
• Approx. total cost per building type	=	$ 1,000

Building Type: **<u>DENTAL CLINIC BUILDING</u>**

Building number: 5660

Ventilation Scheme:

• Number of louvers	=	16
• Approx. cost	=	$ 2,000

Building Type: **<u>PM ADMINISTRATION BUILDING</u>**

Building number: 6734

Ventilation Scheme:

• Number of louvers	=	12
• Approx. cost	=	$ 2,000

Building Type: **<u>ADMINISTRATION GENERAL PURPOSE</u>**

Building numbers included: (2 total)

6518, 6608

Ventilation Scheme:

• Number of louvers per building	=	2
• Total number per building type	=	4
• Approx. cost of louvers per building	=	$250
• Approx. total cost per building type	=	$ 1,000

Building Type: **<u>GYMNASIUMS</u>**

Building numbers included: (4 total)

5631, 5731, 5831, 5953

Ventilation Scheme:

• Number of louvers per building	=	6
• Total number per building type	=	24

- Approx. cost of louvers per building = $1,000
- Approx. total cost per building type = $ 4,000

NO VENTILATION

Some buildings do not require any ventilation due to their low value. These are:

5722	Gas Station
5882	Gas Station
5926	Gas Station
5723	Oil Storage
5930	Oil Storage
6897	Lavatory Building
5721	Lispatch Building
5887	Dispatch Building
5925	Dispatch Building

APPENDIX B:

FORT DIX BEDDING PLAN

REACT. PERIOD	LAYAWAY PERIOD	
	LESS THAN 1 YEAR	GREATER THAN 1 YEAR
LESS THAN 45 DAYS	MINIMAL & PREFERRED: All mattresses to remain in current rooms. Place individual mattresses into storage bags. Stack on edge against wall centrally located within room.	PREFERRED: Transport all mattresses to designated block mess halls. Remove and store dining room tables and chairs in central location within mess hall. Place individual mattresses into storage bags. Stack on edge no more than two mattresses high. MINIMAL: All mattresses to remain in current rooms. Place individual mattresses into storage bags. Stack on edge against wall centrally located within room.
GREATER THAN 45 DAYS	PREFERRED: Transport all mattresses to designated block mess halls. Remove and store dining room tables and chairs in central location within mess hall. Place individual mattresses into storage bags. Stack on edge no more than two mattresses high. MINIMAL: All mattresses to remain in current rooms. Place individual mattresses into storage bags. Stack on edge against wall centrally located within room.	MINIMAL & PREFERRED: Transport all mattresses to designated block mess halls. Remove and store dining room tables and chairs in central location within mess hall. Place individual mattresses into storage bags. Stack on edge no more than two mattresses high.

APPENDIX C:

FORT DIX DO-NOTHING FACILITY LISTING

Cat Code	Building #	Description
123-10	6739	Gas Station
872-35	6740	Dispatch Building
179-90	5717	Training Classroom Str.
730-55	5747	Waiting Shelter
214-50	5724	Grease Rack
"	5883	"
"	5947	"
"	5948	"
"	5949	"
214-54	5729	Wash Platform
"	5730	"
"	5885	"
"	5886	"
"	5941	"
"	5942	"
"	5943	"
"	5944	"
"	5945	"
"	5946	"

APPENDIX D:

STEAM HEATING SYSTEM MODELING

Introduction

The steam heating system at Fort Dix consists of boiler plants located in buildings 5252, 5426, and 5881, and a heat recovery incinerator (HRI) located in building 5891. All of the boilers in the boiler plants are oil-fired, and those in the HRI are fired with solid waste with natural gas used as an auxiliary fuel. Boiler manufacturers and capacities for the boiler plants and the HRI are given in Table D1. The steam distribution system is a direct-burial steel Ricwil system with supply and return lines in separate conduits. It is approximately 20 years old. Plastic condensate return lines were replaced with metallic lines in recent years. The system is not cathodically protected. In addition, there are no sump pumps in, or electrical service to, any of the approximately 60 manholes and building entry pits.

The boiler plant in building 5881 and the HRI serve the 5700, 5800, and 5900 block areas of the doughboy loop while the boiler plants in buildings 5252 and 5426 serve the remainder of the Fort Dix high-pressure steam requirements (except for the laundry facility, which has its own steam generation plant. A diagram of the Fort Dix steam heating system is given in Figure D1. A project that was recently completed provides a steamline link between the 5600 and 5700 block areas of the doughboy loop. Theoretically, the entire high-pressure steam heating system will be interconnected so steam generated at any of the boiler plants or the HRI can be received at any location within the network. This is important as it means that a single boiler plant may be able to supply all of the high-pressure steam heating requirements under realignment conditions if the total demand is reduced sufficiently. The remaining boiler plants could then be deactivated to reduce required operation and maintenance costs. Values for actual steam production, as reported in the boiler logs for each of the boiler plants and the HRI from November 1988 to October 1989 are given in Table D2.

Table D1

Fort Dix Boiler Information

Building	Quantity	Manufacturer	Unit Capacity (lb/hr)
5252	3	The Bigelow Co.	40,000
5426	3	Erie City Iron Works	55,000
	1	E. Keeler Co.	50,000
5881	4	E. Keeler Co.	50,000
5891	4	Energy Recovery Inc.	7,000

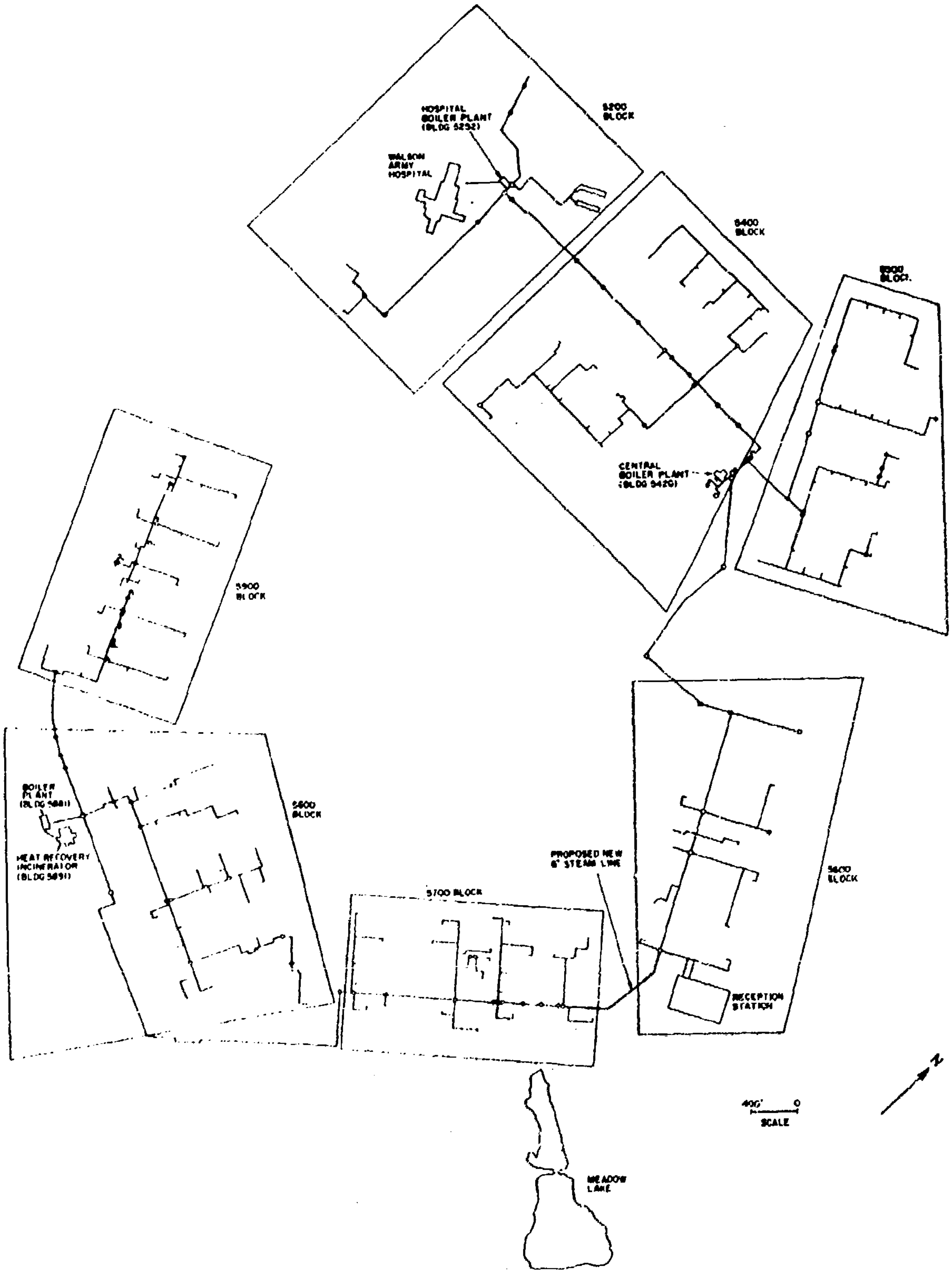

Figure D1. Fort Dix steam heating distribution system.

Table D2

Fort Dix Steam Production (x 1000 lbs)

Month	UPPER LOOP: Building 5252	Building 5426	Upper Loop Subtotal	LOWER LOOP: Building 5881	Building 5891	Lower Loop Subtotal	Grand Total
Nov 1988	0	33,604	33,604	28,305	6,459	34,764	68,368
Dec 1988	0	49,028	49,028	37,435	6,277	43,712	92,740
Jan 1989	0	50,779	50,779	37,627	5,902	43,529	94,308
Feb 1989	0	48,071	48,071	36,392	5,543	41,935	90,006
Mar 1989	0	47,414	47,414	41,752	6,316	48,068	95,482
Apr 1989	0	35,465	35,465	23,055	6,246	29,301	64,766
May 1989	0	26,584	26,584	20,619	6,773	27,392	53,976
Jun 1989	0	24,966	24,966	14,335	7,971	22,306	47,272
Jul 1989	1,416	26,872	28,288	6,447	7,742	14,189	42,477
Aug 1989	19,985	6,468	26,453	11,569	8,824	20,393	46,846
Sep 1989	17,359	5,706	23,065	11,099	7,505	18,604	41,669
Oct 1989	0	27,296	27,296	19,154	7,032	26,186	53,482
Total	38,760	382,253	421,013	287,789	82,590	370,379	791,392

Techdata costs database data for Fiscal Year (FY) 1989 show total expenditure for operation of all oil-fired high-pressure boiler plants (J account) to have been $4,224,310. The corresponding maintenance expenditures for these boiler plants (K Account) for FY 1989 was $2687. Thus the total operation and maintenance cost for these boiler plants for FY 1989 was $4,226,997. The total steam production reported in the Techdata database for FY 1989 was 638,126 MBtu. Thus the cost of steam production in FY 1989 averaged $6.62/MBtu of steam produced. For 110 (psig) steam, this becomes $7.88/1000 lb of steam produced. It should be noted that the figures reported in the Techdata database do not include the steam produced and the associated expenses for the HRI, but do include the steam produced and the associated expenses for the two boilers at the laundry facility boiler plant (building 5324). Also, the steam production reported in the Techdata database is considerably lower than that reported in the boiler logs for buildings 5252, 5426, and 5881 alone. The source of this discrepancy is unknown, but it is assumed that the costs reported in the Techdata database are based on the same rationale as the reported steam production. Therefore, the figure of $7.88/1000 lb of steam produced can be used to arrive at a reasonable estimate of the cost for heating a given building once that building's steam requirements have been determined. It should be noted that the Techdata costs database data have been used only to obtain a unit cost for steam production. For all other purposes in this report, actual boiler log steam production data have been used. The determination of building steam requirements for any particular building type will be discussed in the following section.

Modeling Process

Modeling of the steam heating system allows a determination to be made of the total steam production requirements and the associated costs for a variety of realignment scenarios. This knowledge is important because it allows a determination to be made of the total number of boilers required to meet the steam demand for each of these scenarios and, hence, the feasibility of deactivating individual boiler plants. It can also provide guidance on the relative merits of maintaining some degree of heat to deactivated buildings, and in the best selection of those buildings which are to remain occupied.

Modeling of the steam heating system is a two-step process. The first step involves the use of a microcomputer-based program called HEATLOAD to determine the amount of steam that must be delivered to any individual building to meet that particular building's heating requirements. This determination is made based on a number of linear regression equations that relate daily heating energy consumption for individual building categories to the number of daily heating degree days. These equations were obtained as a result of a study (the Fixed Facilities Energy Consumption Investigation) performed by USACERL at several Army installations in 1979.[1] The particular building categories and their respective linear regression equations are given in Table D3. Outputs from the HEATLOAD program include the maximum and average heat loads (in MBtu/hr) by building category on a monthly and an annual basis for the particular weather data used as input to the program. All weather data used in modeling the Fort Dix steam heating system was obtained from the U.S. Air Force Environmental Technical Applications Center (ETAC) at Scott Air Force Base, IL, and is based on weather data from McGuire Air Force Base, NJ.

[1] B.J. Sliwinski, E. Elischer, *Analysis of Facilities' Energy Use Patterns*, USACERL TR E-186/ADA132527 (USACERL, August 1983).

The second step in the steam heating system modeling process involves the use of the HEATLOAD output as input to the Steam Heat Distribution Program (SHDP). SHDP is a microcomputer-based pressure-flow thermal efficiency program developed through the joint efforts of the Naval Civil Engineering Laboratory (NCEL), the Naval Postgraduate School, and Oak Ridge (TN) National Laboratory. Its purpose is to accurately model large steam heat distribution systems. Inputs to SHDP include distribution line nodes, line diameters and lengths, boiler plant supply pressure, and trap leakage data, as well as the individual building loads calculated by HEATLOAD. SHDP uses an iterative solution to determine the total steam output required from the boiler plant, with a breakdown of the distribution losses and a determination of the distribution efficiency.

Before SHDP can be used with confidence to model the Fort Dix steam heating system for a variety of realignment scenarios, it is necessary to verify the model with existing data. This has been done using boiler log and weather data for the lower doughboy loop (5700, 5800, and 5900 blocks) for November 1988 to October 1989. For the purposes of modeling the lower loop, it has been assumed that the HRI produces 10,000 lb of steam per hour, with the remainder of the steam demand produced by the boiler plant in Building 5881. All buildings in the lower loop are assumed to be maintained at 65 °F. Average monthly building steam requirements, as determined by HEATLOAD based on weather data for the period November 1988 to October 1989, are shown in Table D4. The corresponding SHDP predictions of monthly steam demand and the sum of the actual monthly boiler log data for Building 5881 and the HRI are plotted in Figure D2. While there are a number of factors that can influence actual steam consumption and demand, it can be seen from this figure that SHDP provides a reasonable approximation of the actual monthly steam demand. When summed to provide actual and predicted steam consumption values on an annual basis, the SHDP predictions and actual boiler log data differ by less than 5 percent. It is thus assumed that HEATLOAD and SHDP may be used with confidence to provide estimates of steam production requirements under a variety of deactivation scenarios.

Table D3

HEATLOAD Building Categories and Energy Consumption Equations

Building Category	Energy Consumption Equation
Troop Housing Barracks	$E_h = 130.50 + (15.99 \times HDD_d)$
Troop Housing Barracks (after 1966)	$E_h = 81.91 + (7.40 \times HDD_d)$
Troop Housing Barracks (modular)	$E_h = 295.90 + (34.21 \times HDD_d)$
Dining Facilities	$E_h = 231.80 + (12.42 \times HDD_d)$
Family Housing	$E_h = 105.60 + (20.02 \times HDD_d)$
Administration/Training	$E_h = 76.71 + (18.97 \times HDD_d)$
Medical/Dental	$E_h = 254.40 + (24.31 \times HDD_d)$
Storage	$E_h = 35.70 + (36.10 \times HDD_d)$
Production/Maintenance	$E_h = 138.40 + (35.73 \times HDD_d)$
Fieldhouses/Gymnasiums	$E_h = 73.69 + (32.40 \times HDD_d)$

where E_h = Daily Heating Energy

and HDD_d = Daily Heating Degree Days

Table D4

Fort Dix Steam Demand (Novemeber 1988 - October 1989)

BUILDING TYPE	SQ FT	Ave Nov LB/HR STM @ 120 PSIA	Ave Dec LB/HR STM @ 120 PSIA	Ave Jan LB/HR STM @ 120 PSIA	Ave Feb LB/HR STM @ 120 PSIA	Ave Mar LB/HR STM @ 120 PSIA	Ave Apr LB/HR STM @ 120 PSIA	Ave May LB/HR STM @ 120 PSIA	Ave Jun LB/HR STM @ 120 PSIA	Ave Jul LB/HR STM @ 120 PSIA	Ave Aug LB/HR STM @ 120 PSIA	Ave Sep LB/HR STM @ 120 PSIA	Ave Oct LB/HR STM @ 120 PSIA
MESS HALL	11,323	273.1	416.8	403.4	433.6	355.5	217.6	105.9	30.3	29.4	29.4	56.3	142.0
BARRACKS PRE-66	43,653	617.6	872.3	848.7	902.5	763.9	520.2	321.0	188.2	185.7	186.6	233.6	385.7
ADMIN HQ	9,840	150.4	223.5	216.8	231.9	192.4	122.7	65.5	26.9	26.1	26.1	40.3	84.0
ADMIN/STOR	12,194	186.6	277.3	268.9	287.4	238.7	152.1	80.7	33.6	32.8	32.8	43.6	104.2
MOTOR POOL	4,787	137.0	204.2	197.5	211.8	176.1	110.9	58.8	23.5	23.5	23.5	36.1	75.6
GYM	20,648	516.8	714.3	695.8	737.0	630.3	442.0	288.2	185.7	184.0	184.9	221.0	338.7
DISPENSARY	3,707	60.5	79.0	77.3	80.7	71.4	53.8	39.5	30.3	30.3	30.3	33.6	44.5
PX	4,800	121.0	189.1	183.2	196.6	160.5	95.0	42.0	6.7	5.9	5.9	18.5	59.7
BRIG HQ	6,137	94.1	139.5	135.3	144.5	120.2	76.5	40.3	16.8	16.8	16.8	25.2	52.1
CHAPEL	7,762	118.5	176.5	171.4	183.2	152.1	96.6	51.3	21.0	21.0	21.0	31.9	66.4
DENTAL CLINIC	10,875	178.2	231.1	226.1	237.0	208.4	158.0	116.8	89.1	88.2	88.2	98.3	129.4
THEATER	17,437	437.0	602.5	588.2	622.7	532.8	373.1	243.7	157.1	155.5	155.5	186.6	285.7
CHILD CARE / EMSC	27,578	421.0	626.9	607.6	650.4	539.5	342.9	183.2	75.6	73.9	74.8	112.6	235.3
RECEPTION CENTER	131,000	2001.7	2975.6	2887.4	3091.6	2562.2	1630.3	869.7	360.5	352.1	354.6	534.5	1116.0
5219	5,338	81.5	121.0	117.6	126.1	104.2	66.4	35.3	15.1	14.3	14.3	21.8	45.4
5240	31,130	779.8	1076.5	1049.6	1111.8	950.4	666.4	435.3	279.8	277.3	278.2	332.8	510.1
HOSPITAL	427,165	6989.1	9068.9	8080.7	9316.0	8185.7	6195.0	4572.3	3486.6	3467.2	3473.1	3857.1	5098.3
5256	15,486	235.3	331.9	323.5	343.7	290.8	198.3	122.7	71.4	70.6	71.4	89.1	147.1
5257	11,360	172.3	243.7	237.0	252.1	213.4	145.4	89.9	52.9	52.1	52.1	65.5	107.6
5275	27,137	210.9	289.9	282.4	299.2	256.3	191.5	119.3	78.2	78.2	78.2	92.4	139.5
5407	2,578	39.5	58.8	57.1	60.5	50.4	31.9	16.8	6.7	6.7	6.7	10.9	21.8
5408	3,800	58.0	86.6	84.0	89.9	73.9	47.1	25.2	10.1	10.1	10.1	15.1	32.8
5411	30,479	465.5	692.4	672.3	719.3	595.8	379.0	202.5	84.0	81.5	82.4	124.4	259.7
5418	97,838	1495.0	2222.7	2156.3	2308.4	1913.4	1217.5	649.6	269.7	263.0	264.7	399.2	833.6
5429	4,640	75.6	98.3	96.6	100.8	89.1	67.2	49.6	37.8	37.8	37.8	42.0	55.5
5441	39,770	604.2	852.9	830.3	882.4	747.1	508.4	314.3	184.0	181.5	182.4	228.6	377.3
5513	9,230	141.2	210.1	203.4	217.6	180.7	115.1	61.3	25.2	25.2	25.2	37.8	79.0
5523	29,758	454.6	675.6	656.3	702.5	582.4	370.6	197.5	82.4	79.8	80.7	121.8	253.8
T-Type	39,770	601.7	849.6	826.9	879.0	744.5	506.7	313.4	184.0	181.5	182.4	228.6	376.5

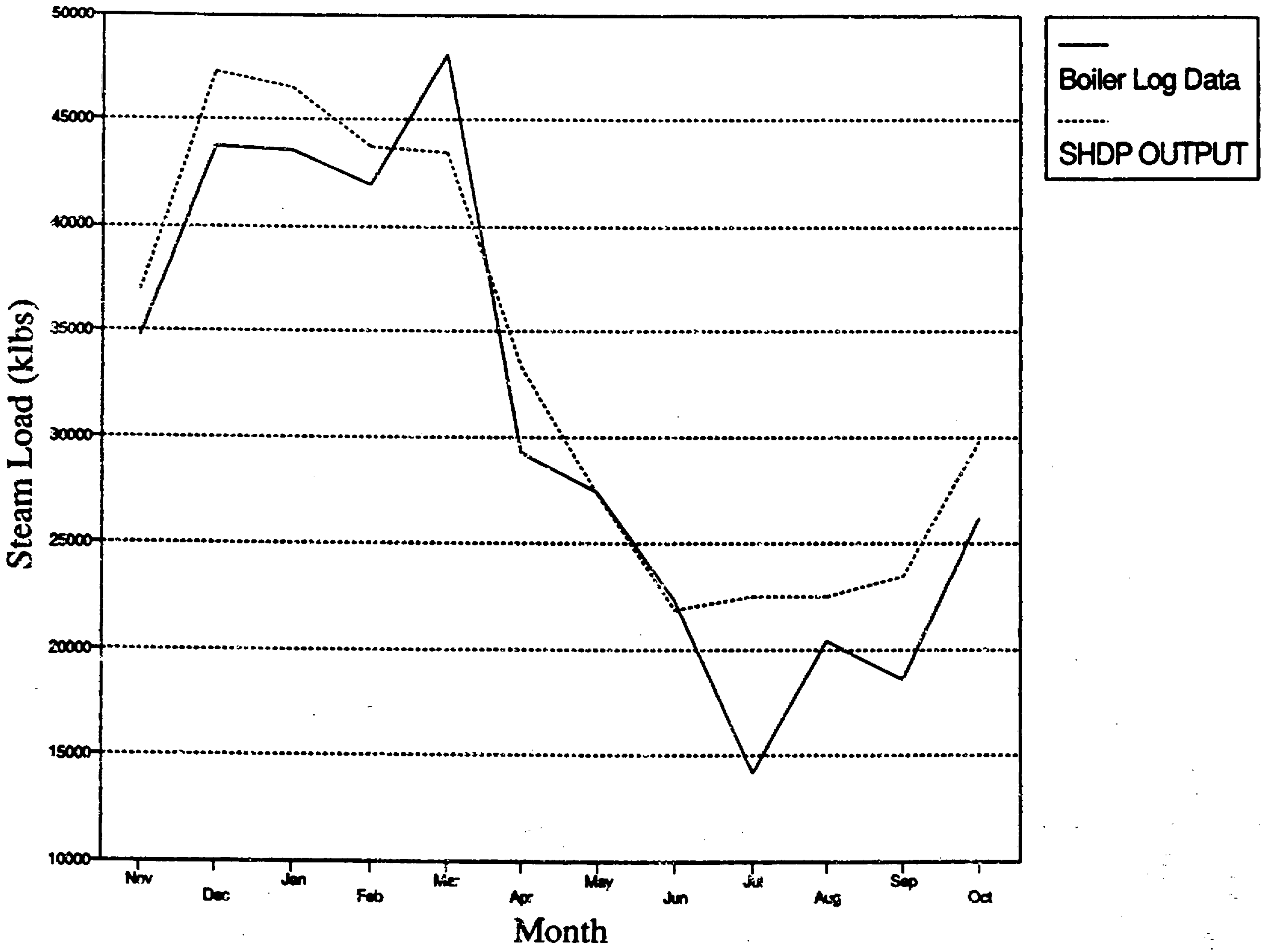

Figure D2. Actual steam produced v. SHDP output (building 5881 and HRI).

Modeling Scenarios

As a means of facilitating the modeling of the various deactivation scenarios and the interpretation of the results, the Fort Dix steam heating system was broken down into six separate steam loops that were analyzed individually. The interdependence of the various loops was preserved in the SHDP models. The individual loop designators and the corresponding Fort Dix areas are as follows: Loop A - 5900 block; Loop B - 5800 block; Loop C - 5700 block; Loop D - 5600 block; Loop E - 5500 block; and Loop F - 5200 and 5400 blocks. Current understanding of the Fort Dix realignment plans calls for no buildings to remain occupied in Loop A and only a very few buildings in Loops B, C, and D to remain occupied. There is a possibility that some of the T-barracks in Loops E and F may be deactivated as well, although no definite plans exist at this time. For modeling purposes, it is assumed that the lower doughboy loop (Loops A, B, and C) is served by the HRI at 10,000 lb steam per hour with the remainder of the steam demand supplied by the boiler plant in Building 5881. It is assumed that the upper doughboy loop (Loops D, E, and F) is supplied steam from the central boiler plant in Building 5426. The boiler plant in Building 5252 (the Hospital Boiler Plant) was not considered in the modeling process as it currently produces only a small amount of the total steam used by the upper dougnboy loop and is not used concurrently with the central boiler plant in building 5426.

Buildings in the doughboy loop are modeled as being heated to 65 °F(normal occupied status), heated to 45 °F(heated unoccupied status), or not heated. All HEATLOAD steam supply requirements for the deactivation scenarios are based on 30-year average weather data. The average and maximum annual steam demand by building category as determined by HEATLOAD for the 30-year average weather data are given in Table D5 for a 65 °F base temperature and in Table D6 for a 45 °F base temperature. It might be noted that this data can be used to estimate the costs of heating any individual building type. As an example, consider a rolling pin barracks (pre-1966). HEATLOAD predicts an average annual steam demand of 501.7 lb/hr for heating to 65 °F(Table D5). Over a year this comes to a total demand of 4,394,892 lb steam. Using the figure previously quoted for steam cost ($7.88 per 1000 lb steam) provides for an annual cost of approximately $34,630. This figure represents the cost for the steam actually used by the building. The amount of steam required from the boiler plant to satisfy the steam demand of an individual rolling pin barracks will be greater than the building demand by a factor inversely proportional to the distribution efficiency. Distribution efficiencies for the realignment scenarios modeled here range from approximately 13 percent to 51 percent. Hence the total estimated cost for heating a single rolling pin barracks to 65 °F ranges from approximately $67,900 to $266,380.

A total of eight different deactivation scenarios have been modeled. The conditions for these different realignment scenarios are as follows:

- Scenario 1 - All buildings in all loops are heated to 65 °F. Individual building steam demands are given by the HEATLOAD average annual demands. This scenario is indicative of normal current operation and is provided as a basis for comparison with the other scenarios.

- Scenario 2 - All buildings in all loops are heated to 45 °F. Individual building steam demands are given by the HEATLOAD average annual demands. The use of the 45 °F building temperature for the E and F loops is intended to provide some approximation to the probability that some of these buildings may be deactivated while the majority will remain occupied. At this time there is not sufficient knowledge of the realignment plans for these two loops to make more a precise estimate of steam demand in these areas.

Table D5

Fort Dix Steam Demand (65 °F Base Temperature)*

Building Type	Sq Ft	Average lb/hr Steam (@ 120 psia)	Maximum lb/hr Steam (@ 120 psia)
Mess Hall	11,323	207.6	722.7
Barracks (Pre-1966)	40,653	501.7	1415.1
Admin HQ	9,840	116.8	379.0
Admin/Storage	12,194	145.4	469.7
Motor Pool	4,787	105.9	346.2
Gym	20,648	427.7	1132.8
Dispensary	3,707	52.1	116.8
Px	4,800	89.9	333.6
Brig HQ	6,137	73.1	237.0
Chapel	7,762	92.4	299.2
Dental Clinic	10,875	153.8	343.7
Theater	17,437	361.3	957.1
Child Care/EMSC	27,578	327.7	1063.0
Reception Center	131,000	1558.8	5050.4
Bldg 5219	5,338	63.9	205.9
Bldg 5240	31,130	644.5	1708.4
Hospital	427,165	6043.7	13498.3
Bldg 5256	15,486	190.8	538.7
Bldg 5257	11,360	140.3	395.0
Bldg 5275	27,137	175.6	457.1
Bldg 5407	2,578	31.1	99.2
Bldg 5408	3,800	45.4	146.2
Bldg 5411	30,479	363.0	1174.8
Bldg 5418	97,838	1163.9	3772.3
Bldg 5429	4,640	65.5	146.2
Bldg 5441	39,770	490.8	1384.0
Bldg 5513	9,230	110.1	355.5
Bldg 5523	29,758	353.8	1147.1
T-Type Barracks	39,770	481.5	1377.3

*Based on 30-year average weather data.

Table D6

Fort Dix Steam Demand (45 °F Base Temperature)*

Building Type	Sq Ft	Average lb/hr Steam (@ 120 psia)	Maximum lb/hr Steam (@ 120 psia)
Mess Hall	11,323	142.0	465.5
Barracks (Pre-1966)	40,653	385.7	959.7
Admin HQ	9,840	84.0	248.7
Admin/Storage	12,194	104.2	308.4
Motor Pool	4,787	75.6	226.9
Gym	20,648	338.7	781.5
Dispensary	3,707	44.5	84.9
Px	4,800	59.7	212.6
Brig HQ	6,137	52.1	155.5
Chapel	7,762	66.4	195.8
Dental Clinic	10,875	130.3	248.7
Theater	17,437	285.7	659.7
Child Care/EMSC	27,578	235.3	696.6
Reception Center	131,000	1116.8	3310.1
Bldg 5219	5,338	45.4	135.3
Bldg 5240	31,130	510.1	1178.2
Hospital	427,165	5100.0	9783.2
Bldg 5256	15,486	147.1	365.5
Bldg 5257	11,360	107.6	268.1
Bldg 5275	27,137	139.5	316.8
Bldg 5407	2,578	21.8	65.5
Bldg 5408	3,800	32.8	95.8
Bldg 5411	30,479	259.7	770.6
Bldg 5418	97,838	834.5	2472.3
Bldg 5429	4,640	55.5	105.9
Bldg 5441	39,770	377.3	938.7
Bldg 5513	9,230	79.0	233.6
Bldg 5523	29,758	253.8	752.1
T-Type Barracks	39,770	376.5	934.5

*Based on 30-year average weather data.

- Scenario 3 - All unoccupied buildings in Loops A, B, C, and D are heated to 45 °F. All other buildings in these loops and all the buildings in Loops E and F are heated to 65 °F. Individual building steam demands are given by the HEATLOAD average annual demands.

- Scenario 4 - All unoccupied buildings in Loops A, B, C, and D are unheated. All other buildings in these loops and all the buildings in Loops E and F are heated to 65 °F. Individual building steam demands are given by the HEATLOAD average annual demands.

- Scenario 5 - Same conditions as Scenario 1 except that individual building steam demands are given by the HEATLOAD maximum annual demands.

- Scenario 6 - Same conditions as Scenario 2 except that individual building steam demands are given by the HEATLOAD maximum annual demands.

- Scenario 7 - Same conditions as Scenario 3 except that individual building steam demands are given by the HEATLOAD maximum annual demands.

- Scenario 8 - Same conditions as Scenario 4 except that individual building steam demands are given by the HEATLOAD maximum annual demands.

Modeling Results

Total steam requirements and individual loop steam requirements (in pounds of steam per hour), and the associated annual costs (based on $7.88 per 1000 lb steam), are shown in Tables D7 through D14 for each of the eight scenarios modeled. Additional scenarios can be approximated from this data by summing individual loop totals from the appropriate existing scenarios. As an example, to approximate the annual average steam production requirements for a scenario in which all unoccupied buildings in Loops A, B, C, and D are unheated, all occupied buildings in these loops and all buildings in Loop F are heated to 65 °F, and all buildings in Loop E are heated to 45 °F, one need simply add the Loop E results from Scenario 2 to the results of Loops A, B, C, D, and F from Scenario 4.

As can be seen from the results given in Tables D7 through D14, the total steam demand could be met for all cases (with the exception of Scenario 5) by the central boiler plant (Building 5426) alone, provided that the ongoing project to link the 5600 and 5700 block areas is completed. Scenario 5 corresponds to a maximum load condition with all buildings being occupied, and as such, is not pertinent to any realistic realignment scenario. A more realistic realignment scenario would produce a total steam demand ranging from the conditions of Scenario 4 (66,869 lb/hr) to the conditions of Scenario 8 (112,450 lb/hr). Under these conditions, the total steam demand could be met by steady use of two boilers in the central boiler plant with a third boiler on standby for peak load conditions.

It should be noted that the distribution efficiency of a steam heating distribution system depends not only on the distance the steam must travel to reach the load, but also on the density of the load in the area being served. To illustrate this point, consider the difference in lower doughboy loop steam distribution efficiencies between Scenario 1 and Scenario 4. In Scenario 1 all buildings are heated to 65 °F. SHDP gives a value of steam distribution efficiency of 50.7 percent under these conditions. That is, for every 100 lb of steam produced by the boiler plant, 50.7 lb is actually used to satisfy the heating requirements. The energy contained in the remaining 49.3 lb is lost within the distribution system. In Scenario 4, only

Table D7

SHDP Annual Steam Demand and Cost, Scenario 1

Loop	Steam Demand (lb/hr)	Cost ($)
A	14,727	1,016,587
B	14,349	990,494
C	18,594	1,283,522
D	17,448	1,204,415
E	15,220	1,050,618
F	26,401	1,822,429
TOTAL	106,739	7,368,065

Table D8

SHDP Annual Steam Demand and Cost, Scenario 2

Loop	Steam Demand (lb/hr)	Cost ($)
A	12,758	880,669
B	12,183	840,978
C	16,574	1,144,083
D	15,091	1,041,714
E	12,771	881,567
F	23,224	1,603,125
TOTAL	92,601	6,392,136

Table D9

SHDP Annual Steam Demand and Cost, Scenario 3

Loop	Steam Demand (lb/hr)	Cost ($)
A	12,758	880,669
B	12,381	854,646
C	16,728	1,154,714
D	15,164	1,046,753
E	15,220	1,050,618
F	26,401	1,822,429
TOTAL	98.652	6,809,829

Table D10

SHDP Annual Steam Demand and Cost, Scenario 4

Loop	Steam Demand (lb/hr)	Cost ($)
A	0	0
B	6,260	432,120
C	10,962	756,694
D	8,026	554,025
E	15,220	1,050,618
F	26,401	1,822,429
TOTAL	66,869	4,615,886

Table D11

SHDP Annual Steam Demand and Cost, Scenario 5

Loop	Steam Demand (lb/hr)	Cost ($)
A	30,189	2,083,910
B	31,346	2,163,777
C	34,386	2,373,624
D	26,717	1,844,242
E	33,300	2,298,659
F	50,524	3,487,611
TOTAL	206,462	14,251,823

Table D12

SHDP Annual Steam Demand and Cost, Scenario 6

Loop	Steam Demand (lb/hr)	Cost ($)
A	22,508	1,553,700
B	22,898	1,580,621
C	26,549	1,832,646
D	26,717	1,844,242
E	24,360	1,681,542
F	39,215	2,706,964
TOTAL	162,247	11,199,715

Table D13

SHDP Annual Steam Demand and Cost, Senario 7

Loop	Steam Demand (lb/hr)	Cost ($)
A	22,508	1,553,700
B	23,671	1,633,981
C	27,149	1,874,063
D	27,004	1,864,054
E	33,300	2,298,659
F	50,524	3,487,611
TOTAL	184,156	12,712,068

Table D14

SHDP Annual Steam Demand and Cost, Scenario 8

Loop	Steam Demand (lb/hr)	Cost ($)
A	0	0
B	7,831	540,565
C	12,185	841,116
D	8,610	594,338
E	33,300	2,298,659
F	50,524	3,487,611
TOTAL	112,450	7,762,289

the few buildings remaining occupied in the lower doughboy loop are heated to 65 °F. The remaining buildings in the lower doughboy loop are unheated. Hence, the load density (i.e., the number of heated buildings in the given area) is considerably lower than in Scenario 1. The lower doughboy loop steam distribution efficiency for Scenario 4 is given by SHDP to be 12.8 percent. That is, for every 100 lb of steam produced by the boiler plant, only 12.8 lb is actually used to satisfy the heating requirements. The energy contained in the remaining 87.2 lb is lost within the distribution system. Thus it is advisable to position the heating load as close as possible to the steam source, and to provide the greatest load density as possible.

Steam Heating System Recommendations

It is recommended that the basic realignment heating scenario correspond to that of Scenario 4. That is, no heat is to be provided to unoccupied buildings. It is also recommended that the ongoing project to provide a steamline link between the 5600 and 5700 block areas of the doughboy loop be completed as soon as possible. This will allow all steam heating demands to be met by the central boiler

plant. It is recommended that all boilers in buildings 5252 and 5881 be placed in a dry layup status as described in Chapter 5 under "Boiler Plants." Also, one boiler in the central heating plant (Building 5426) should be placed in dry layup. The particular boiler in the central heating plant to be layed up in a dry status should be the one in the worst condition. Two of the boilers in the central heating plant should be kept in active use. The remaining boiler may be kept in a standby status to meet peak load requirements. This may be accomplished by circulating treated feedwater heated in a tube-in-shell heat exchanger by steam drawn from one of the active boilers. The requisite plumbing modifications and associated costs will depend on the particular physical layout and features of the particular boilers involved. This serves the purpose of preventing corrosion in the standby boiler as well as keeping the boiler refractory warm to prevent refractory damage due to thermal stresses when the boiler is brought on line. The three boilers not in dry layup should be rotated on an annual basis so no boiler remains in standby status for more than 1 year at a time. Since the total steam demand can be met by the central boiler plant, there is no need for steam to be produced by the HRI. It could be placed in dry layup as far as steam demand is concerned. If it is deemed necessary to maintain operation of the HRI to meet community solid waste management needs, then it is recommended that a steamline link be provided between the 5900 and 5200 blocks. This would shorten the distance that the steam produced at the HRI would have to travel to reach a heating load, and thus would increase the steam distribution efficiency.

Long-range (1993-1994) Fort Dix realignment plans call for the activities left on the doughboy loop to be moved north of 8th Street. This would decrease the distance from the central heating plant to the thermal load that these activities present, and would place them in a higher heating-load-density area. These two effects would serve to greatly increase overall steam distribution efficiency. In the interim, thought should be given to moving these activities as close as possible to the central heating plant, possibly by consolidating them in the 5600 block area. Installation of stand-alone heating units in those few buildings remaining open is not considered a feasible option given the relatively short time before the activities associated with these buildings move north of 8th street.

APPENDIX E:

PROCEDURE FOR COMPUTING COSTS FOR STEAM DISTRIBUTION SYSTEM

Since pipe sizes and numbers of manholes will vary throughout the system, the cost per linear foot may vary throughout the system. To develop costs for specific sections of the steam distribution system:

1. Determine the number of manholes (N) and number of linear feet of piping (L), including supply and return in the section to be analyzed.

2. Decide which criteria to use. For Preferred Warm/Hot, use Table E1. For Preferred Cold, use Table E2. For Minimal Warm/Hot, use Table E3. For Minimal Cold, use Table E4.

3. Follow the table to calculate costs for deactivation, periodic M&R, and reactivation procedures.

Table E1

Costs for Preferred Warm/Hot Steam Distribution System Procedures

Variables used:

N = Number of manholes in section to be analyzed
L = Number of linear feet of piping (incl. supply and return) in section to be analyzed
RC = Replacement cost of section of system (from Table E5)

DEACTIVATION

ACTIVITY	N OR L		% FACTOR		ACTIVITY COST($)		TOTAL COST
Manhole Inspection	N	*	1.0	*	175.00	=	______
Lab/pressure tests	N	*	1/10	*	300.00	=	______
Install power & pumps	N	*	1.0	*	1200.00	=	______
Replace gaskets/packing	N	*	1/3	*	100.00	=	______
Replace corr. internals	N	*	1/6	*	150.00	=	______
Caulk wall penetrations	N	*	1/3	*	40.00	=	______
Repair pipe/casing leak	N	*	1/15	*	3000.00	=	______
Replace conduit system			0.0025	*	RC	=	______
	TOTAL DEACTIVATION COST (ADD UP THE ABOVE COSTS)					=	______

PERIODIC M&R (ANNUAL COST)

ACTIVITY	N OR L		% FACTOR		ACTIVITY COST ($)		TOTAL COST
Manhole Inspection (4x per year)	4N	*	1.0	*	40.00	=	______
Incidental M&R	4N	*	1/10	*	100.00	=	______
	TOTAL PERIODIC COST (ADD UP THE ABOVE COSTS)					=	______

REACTIVATION COST = $0.00

Table E2

Costs for Preferred Cold
Steam Distribution System Procedures

Variables used:

N = Number of manholes in section to be analyzed
L = Number of linear feet of piping (incl. supply and return) in section to be analyzed
RC = Replacement cost of section of system (from Table E5)

DEACTIVATION

ACTIVITY	N OR L		% FACTOR		ACTIVITY COST		TOTAL COST
Manhole Inspection	N	*	1.0	*	175.00	=	______
Lab/pressure tests	N	*	1/10	*	300.00	=	______
Install power & pumps	N	*	1.0	*	1200.00	=	______
Replace gaskets/packing	N	*	1/3	*	100.00	=	______
Replace corr. internals	N	*	1/6	*	150.00	=	______
Caulk wall penetrations	N	*	1/3	*	40.00	=	______
Repair pipe/casing leak	N	*	1/15	*	3000.00	=	______
Replace conduit system			0.0025	*	RC	=	______
Shut down/drain lines	L	*	1.0	*	0.0375	=	______
	TOTAL DEACTIVATION COST (ADD UP THE ABOVE COSTS)					=	______

PERIODIC M&R (ANNUAL COST)

ACTIVITY	N OR L		% FACTOR		ACTIVITY COST		TOTAL COST
Manhole Inspection	4N	*	1.0	*	20.00	=	______
Incidental M&R	4N	*	1/30	*	100.00	=	______
	TOTAL PERIODIC COST (ADD UP THE ABOVE COSTS)					=	______

REACTIVATION COST = L * $0.0625

Table E3

Costs for Minimal Warm/Hot Steam Distribution System Procedures

Variables used:

N = Number of manholes in section to be analyzed
L = Number of linear feet of piping (incl. supply and return) in section to be analyzed
RC = Replacement cost of section of system (from Table E5)

DEACTIVATION

ACTIVITY	N OR L		% FACTOR		ACTIVITY COST ($)		TOTAL COST
Manhole Inspection	N	*	1.0	*	100.00	=	_______
Replace gaskets/packing	N	*	1/3	*	100.00	=	_______
Replace corr. internals	N	*	1/6	*	150.00	=	_______
	TOTAL DEACTIVATION COST (ADD UP THE ABOVE COSTS)					=	_______

PERIODIC M&R (ANNUAL COST)

ACTIVITY	N OR L		% FACTOR		ACTIVITY COST($)		TOTAL COST
Manhole Inspection (2X per year)	2N	*	1.0	*	40.00	=	_______
Incidental M&R	2N	*	1/10	*	100.00	=	_______
	TOTAL PERIODIC COST (ADD UP THE ABOVE COSTS)					=	_______

REACTIVATION COST = RC * 0.025

Table E4

Costs for Minimal Cold Steam Distribution System Procedures

Variables used:

N = Number of manholes in section to be analyzed
L = Number of linear feet of piping (incl. supply and return) in section to be analyzed
RC = Replacement cost of section of system (from Table E5)

DEACTIVATION

	N OR L		% FACTOR		ACTIVITY COST($)		TOTAL COST
Manhole Inspection	N	*	1.0	*	100.00	=	_______
Replace gaskets/packing	N	*	1/3	*	100.00	=	_______
Replace corr. internals	N	*	1/6	*	150.00	=	_______
Shut down/ drain lines	L	*	1.0	*	0.0375	=	_______
	TOTAL DEACTIVATION COST (ADD UP THE ABOVE COSTS)					=	_______

PERIODIC M&R (ANNUAL COST)

ACTIVITY	N OR L		% FACTOR		ACTIVITY COST ($)		TOTAL COST
Manhole Inspection (2x per year)	2N	*	1.0	*	40.00	=	_______
Incidental M&R	2N	*	1/30	*	100.00	=	_______
	TOTAL PERIODIC COST (ADD UP THE ABOVE COSTS)					=	_______

REACTIVATION COST = RC * 0.10

Table E5

Cost Per Linear Foot of Steam Piping

Tabulate total straight footage cost by multiplying linear footage of each diameter of pipe by the straight footage cost from this table. Use the formulas below to calculate total cost.

Diameter (in)	Straight Footage Cost ($/lin. ft)
1	20.76
2	21.61
3	28.99
4	31.17
5	36.87
6	45.36
8	61.03
10	76.42

Total material cost (incl. fabrication of elbows and tees)
= Straight footage cost * 1.3

Fabrication cost = Total material cost * 2.0

Total cost of project (replacement cost)
= Total material cost + Fabrication Cost

APPENDIX F:

UST COSTS

Table F1

UST Closure Costs

Temporary closure:--- $3000-$6000

Includes tank emptying, cleaning, capping lines, and periodic inspection.

Permanent closure - in place:-- $10,000-$20,000

Includes $2000-$5000 for construction management, removal of product, excavation to top of tank, disconnection and removal of associated tank lines, capping and isolation of associated equipment, tank cleaning, filling with inert material, restoration of tank area, and periodic inspection.

Permanent closure - tank removal:--- $10,000-$20,000

Includes $2000-$5000 for construction management, removal of product, disconnection and removal of associated tank lines, tank cleaning, rinsing, tank excavation and removal, tank transport and disposal, backfilling and restoration of tank area.

Small Tank Closing:-- $4000-$8000.
This cost applies to small capacity USTs (1000 gallons or less), whether left in place or removed.

Table F2

Costs for UST Closure-Related Field Work

Hydrogeologic site study:-- $1000-$2000

Includes $50-$100/hour for a hydrologist. The higher rates are expected for a more experienced or certified professional.

Preliminary investigation of suspected leak-- $4000-$10,000

Includes $150-$200/hour for backhoe and operator, $2000-$2500/day for excavation equipment with operators, $1000-$1500/day for drilling equipment, and $50-$100/hour for management.

Testing tank integrity-- $2000-$3000

Includes $40-$70/hour for engineering oversight, $900-$1500/day for test contractors, $300-$800 per tank test, $75-$150 per line test and leak detector test.

Table F3

UST Installation-Related Costs

Tank Cost:	
Single-walled steel tank, asphalt- and epoxy-coated with sacrificial anodes	$3000-$4500
Single-walled steel tank, fiberglass-coated	$6000-$7000
Single-walled fiberglass reinforced plastic	$5500-$7000

The price of a double-walled tank is approximately 90 - 100 percent more than the cost of a single-walled tank.

Installation:	
Includes handling, excavation, testing for leaks, anchoring when necessary, bedding and backfilling, piping connections, monitoring, and cathodic protection systems, etc.	$5000-$8000
Cost of Other Items:	
Sensor system, between-wall tank/pipe	$400-$1800
Electronic inventory control for multiple tanks	$4500-$7500
Contractor-supplied tank test	$400-$1300
Drilling cost for each monitoring well	$400-$700
Electronic monitoring system for wells	$900-$1200
Electronic gas and petroleum sensor for well	$700-$2500

APPENDIX G:

FORT DIX UST ISSUES

Affected Tanks

The Fort Dix petroleum products storage system consists of a number of aboveground and underground storage tanks of various sizes holding several fuel types, including No. 2 and No. 6 fuel oil, gasoline, and diesel fuel. A listing of the petroleum products storage tanks in the area affected by the realignment is given in Table G1. These tanks are either associated directly with a building scheduled for deactivation or are associated with a boiler plant that may be deactivated due to reduced steam heating demand under various realignment scenarios. Tanks listed in Table G1 having an ID number beginning with the letter "A" are currently not in use, whereas tanks having an ID number beginning with the letter "E" are currently in use. Tanks whose ID number contains a number following the "A" or "E" (first character) refer to UST for which information is contained in the USACERL UST survey database. These are, in general, large UST having capacities greater than 1000 gallons.

As can be seen from the ID number information in Table G1, data is available in the USACERL UST database for 13 of the UST in the affected area. According to the database, all of these tanks are made of steel and are of single-wall construction. All of them are painted externally and some of the them are lined internally. The leak potential index (LPI) ratings for these tanks range from 2.5 to 3.2, placing them all in the medium-potential-for-leakage category. The tanks range from 18 to 49 years old. Ten of these tanks are currently in use. Tank A71 has not been used since 1975 and apparently still contains about 305 gallons of motor gasoline (MOGAS). The other two inactive tanks, A57 and A72, have been empty since 1981 and 1975, respectively.

Cost of UST Closure

According to the New Jersey Department of Environmental Protection (NJDEP), tank decommissioning costs range from $4000 to $9000, while costs for tank site assessment vary from $2000 to $10,000. Since these figures are compatible with the cost ranges given in Appendix F, the tank closure costs for Fort Dix have been based on the figures in Table F1.

These costs do not include environmental cleanup costs, which are estimated to be about $50,000 to over $1,000,000 per tank site, depending on the site's contamination complexity.

Discussion in this section will be limited to the 13 large USTs in the affected area for which data exist in the USACERL UST database.

Tank size and the number of tanks at a site are important factors in determining closure cost. Larger tanks cost more to close in general than do smaller ones. Also, if a site contains more than one tank, the cost for closure on a per-tank basis is less than for a single tank site. Tanks A71 and A72, and tanks E38, E39, and E40, are located at buildings 6739 and 5252, respectively. The other eight tanks are located at individual sites. Therefore, a total of 10 UST sites must be evaluated.

As can be seen from Table F1, the cost for permanent closure of a 10,000 gallon tank located on a single-tank site ranges from $10,000 to $20,000. A tank with a capacity less than 10,000 gallons (but greater than 1000 gallons) should cost somewhat less than this range. To account for this difference, a

Table G1

Affected Petroleum Products Storage Tanks

Location	Above/Underground	ID Number	Contents	Capacity
5252-1	Underground	E38	#6 Fuel Oil	25,000
5252-2	Underground	E39	#6 Fuel Oil	25,000
5252-3	Underground	E40	#6 Fuel Oil	25,000
5426-1	Aboveground	E--	#6 Fuel Oil	760,000
5426-2	Aboveground	E--	#6 Fuel Oil	300,000
5706	Underground	E56	Diesel Fuel	2,000
5720	Underground	A57	Gasoline	5,000
5876-1	Aboveground	E--	#2 Fuel Oil	275
5876-2	Aboveground	E--	#2 Fuel Oil	275
5876-3	Aboveground	E--	#2 Fuel Oil	550
5880	Underground	E58	Unleaded Gas	5,000
5881	Underground	E59	Diesel Fuel	5,000
5881	Aboveground	E--	#6 Fuel Oil	300,000
5882	Underground	E60	Gasoline	5,000
5901	Underground	E61	#2 Fuel Oil	6,000
5920-1	Aboveground	E--	#2 Fuel Oil	275
5920-2	Aboveground	E--	#2 Fuel Oil	275
5926	Underground	E62	Unleaded Gas	5,000
5927	Underground	E63	Diesel Fuel	5,000
5940-1	Aboveground	E--	#2 Fuel Oil	275
5940-2	Aboveground	E--	#2 Fuel Oil	275
6504-1	Aboveground	E--	#2 Fuel Oil	290
6504-2	Aboveground	E--	#2 Fuel Oil	290
6510	Underground	E--	#2 Fuel Oil	1,000
6518	Underground	E--	#2 Fuel Oil	1,000
6520-1	Aboveground	E--	#2 Fuel Oil	275
6520-2	Aboveground	E--	#2 Fuel Oil	275
6521-1	Aboveground	E--	#2 Fuel Oil	275
6521-2	Aboveground	E--	#2 Fuel Oil	275
6523	Underground	E--	#2 Fuel Oil	550
6555	Aboveground	A--	#2 Fuel Oil	275
6574	Aboveground	E--	#2 Fuel Oil	550
6608	Underground	E--	#2 Fuel Oil	550
6621	Underground	A--	#2 Fuel Oil	275
6622-1	Underground	E--	#2 Fuel Oil	1,000
6622-2	Aboveground	E--	#2 Fuel Oil	275
6734	Aboveground	E--	#2 Fuel Oil	300
6735	Aboveground	E--	#2 Fuel Oil	550
6736	Aboveground	E--	#2 Fuel Oil	550
6737	Underground	E--	#2 Fuel Oil	550
6738	Underground	E--	#2 Fuel Oil	550
6739	Underground	A71	Mo-Gas	5,000
6739	Underground	A72	Mo-gas	5,000
6741	Underground	E--	#2 Fuel Oil	1,000
6749	Underground	E--	#2 Fuel Oil	1,000
6884-1	Aboveground	E--	#2 Fuel Oil	275
6884-2	Aboveground	E--	#2 Fuel Oil	275
6885-1	Aboveground	E--	#2 Fuel Oil	275
6885-2	Aboveground	E--	#2 Fuel Oil	275
6897	Aboveground	E--	#2 Fuel Oil	550
6898	Aboveground	E--	#2 Fuel Oil	550

cost reduction ratio of 15 percent has been chosen to determine closing costs for this range of tank size. Thus, the range of costs for permanent closure of a tank in the 1000 to 10,000 gallon range that occupies a single tank site, is $8500 to $17,000. Tanks A57, E56, E58, E59, E60, E61, E62, and E63 fall into this category, having capacities from 2000 to 6000 gallons. Therefore, the closing costs for these 8 tanks will range from $68,000 to $136,000.

If a site contains more than one tank, and each is less than 10,000 gallons, the cost of closing the first tank can be calculated on the basis of the single-tank closure cost ($8500 - $17,000). Each additional tank at the site would contribute an additional one-third of the single-tank closure cost toward the total site closure cost. This factor for estimating costs for closure of a multiple-tank site is commonly used as a rule of thumb by tank closure contractors in determining UST closure costs. This cost estimation method can be applied to tanks A71 and A72 since both are less than 10,000 gallons and located at a single site. This provides a range of closure costs for these two tanks as $11,333 to $22,667.

Closure costs for tanks having a capacity greater than 10,000 gallons may be estimated by adding a 15 percent increment to the closing costs of a single 10,000-gallon tank. Thus, the cost range for permanent closure of a tank of capacity greater than 10,000 gallons is $11,500 to $23,000. Tanks E38, E39, and E40 are all 25,000 gallons and located at a single site (Building 5252). Therefore, the cost range for closure of this site may be determined by applying the one-third ratio rule to the single-tank closing cost range ($11,500 to $23,000). The resulting range of closure costs for this site is $19,166 to $38,334.

Average closing cost for each tank buried at a single site (A57, E56, E58, E59, E60, E61, E62, and E63) is $12,750. Therefore, the average total cost for closure of these eight tanks is thus $102,000. The average closing cost for tanks A71 and A72, located at a single site, is $17,000. The average closing cost for tanks E38, E39, and E40, located at a single site, is $28,750. Thus, the average grand total closing cost for all 13 USTs located in the affected area (for which data are available in the USACERL UST database) is $147,750.

Calculated closure costs are modest figures and do not include clean up costs of soil or groundwater. In case of discovery of a leak in the environment, additional funds ($50,000 to over $1,000,000 per tank site) are needed for the cleanup.

APPENDIX H:

FORT DIX SANITARY SYSTEM ISSUES

Potable Water System

The raw water source is a mixture of surface- and groundwater. Normally it is a 50-50 mix, but in the summer surface water may account for almost 66 percent of total withdrawals. The plant design capacity is 9 million gallons per day (mgd), with a summer and winter average output of 7 mgd and 3 mgd, respectively. The treatment plant uses lime softening all year and a dose of phosphate polymer on an as-needed basis depending on the raw-water quality. Current treatment practices may be impacted by the reduced demand during the deactivation period. Before reactivation, the treatment capability of the plant may have to be analyzed to predict the effect of increased demand. The analysis should select processes to be reinstated, upgraded, or expanded.

From a total of six groundwater wells, two wells are equipped with iron-removal capabilities and the rest are being used as standby resources due to the relatively high iron content in the groundwater at Fort Dix (about 4 mg/l). The standby wells are used mainly for fire flows and flushing mains, based on their proximity to demand location. Before deactivation, wells to be placed on standby status should be identified. Before reactivation, wells should be selectively used to provide enough pressure in areas where pressure-operated flush valves have caused line pressure drops in the past.

The Fort Dix water distribution system crew follows a lightly structured hydrant flushing program, whereby they flush a certain number of critical hydrants twice a year (spring and fall). A more structured hydrant flushing program should be implemented during the reactivation period. Extended monitoring programs for water quality are also recommended during the deactivation period to safeguard against deterioration of water bacteriological quality. Problems of taste and odor are common aspects of systems under low-flow conditions for extended periods.

Wastewater

The Fort Dix collection system comprises gravity lines and 14 lift stations. The collection system is apparently exhibiting some infiltration/inflow (I/I) problems; a moderate to heavy rainfall can increase the flows into the system from 5 mgd to more than 10 mgd, respectively. The average operating conditions are 3 mgd, so a heavy storm could conceivably cause flows that would push the indicator reading over the chart maximum limit of 10 mgd.

The lift stations' current performance needs certain improvements prior to deactivation. Inspection of lines in the vicinity of lift stations for deposits of solids, grit, and sand prior to deactivation is recommended. Some replacement projects are currently being considered for old and critical lift stations (e.g., lift station D). Updating the sanitary sewers map and the benefits of consolidating some small lift stations into one large station for the case of operation and maintenance should be strongly considered as recommended activities during the deactivation period.

The familiarity and participation of the current wastewater treatment plant staff with the new Fort Dix/Fort McGuire tertiary wastewater treatment plant project should be emphasized through more technical training and/or continuing education courses. Mitigation of low-flow condition and flow fluctuation impact on both the current and new wastewater treatment plant is an issue of major importance.

Operational changes to improve plant efficiency should include increased recirculation, flow equalization, and longer settling periods.

Fire Protection

The fire crew maintains a map with hydrant-flow tests for Fort Dix. Flow in the doughboy loop ranges between 2200 and 3200 gallons per minute (gpm), which seems to be ample capacity for present needs.

Selected portions of the water distribution system mains were relined by a contractor during the summer of 1989. The contractor used a 3/16 in. Portland Cement liner which is reported to be very effective in increasing flows through the rehabilitated part of the water distribution system. Further consideration and budgeting should be allowed to continue the water distribution line rehabilitation scheme. The need for such projects could be easily assessed through either hydrant tests or, more extensively, through hydraulic modeling. Periodic assessment of carrying capacity through calibrated hydraulic models could prove to be the best safeguard against firefighting water shortages.

APPENDIX I:

BUILDING MONITORING SYSTEMS

A critical consideration for temporarily inactive building and utility systems is to implement an effective monitoring program. This will help to ensure that deactivated buildings and systems will not be allowed to deteriorate significantly or fall victim to unnecessary damage by human or natural forces. Relying exclusively on personnel to perform inspections and spot checks may be quite expensive but not completely effective since inspectors cannot devote full time to observing any specific facility. A combination of periodic facility site visits by Directorate of Engineering and Housing (DEH) staff and police combined with some sort of automated monitoring system appears to be the most effective means of providing real-time data on building conditions and reporting fire, flooding, and security problems.

The HSQ™ energy monitoring and control system is installed in nearly all buildings in the doughboy loop affected by the base realignment. This system uses a central station (minicomputer) located in the DEH offices. The EMCS is connected to all Fort Dix facilities by a dedicated hardwired network. The condition of this network must be routinely inspected and maintained during the deactivated period to ensure system integrity. The EMCS is probably the least expensive way for installation personnel to monitor buildings for flooding, intrusion, power failure, interior temperature, humidity, failed sump pumps, or other critical components. This system will not remove the necessity for periodic visual inspection of facilities, but it can reduce inspection frequency for certain problems while still providing immediate alarm notification for critical problems such as fire, flooding, or intrusion.

The EMCS has field interface devices (FIDs) located in each building being monitored or controlled. The enclosures of these devices are not sealed against moisture intrusion. It is recommended that the existing FID enclosures be upgraded with a moisture seal (rubber gasket) on the access door, and that all other openings to the boxes for wires and power be sealed to prevent moisture and pest intrusion. All electronics and EMCS enclosures purchased for replacement or expansion of existing equipment should be specified to meet the appropriate NEMA watertight or weatherproof enclosure specifications to ensure proper operation of the enclosed equipment during the layaway period. Inspection of FIDs for moisture and pest intrusion should be a part of the standard inspection of interior electrical equipment. The EMCS components should be inspected for damage, including corrosion, loose connections, power loss, and pest damage. A desiccant should be put in all sealed enclosures and replaced during inspections to prevent moisture damage to electrical components, and to ensure reliable operation.

The EMCS can be modified to provide on/off control of the AHU fans, pumps, and air conditioning compressors used for humidity control, and forced ventilation in selected facilities. Appropriate facilities include the gymnasiums (for floor preservation), mess halls (if used for mattress storage), reception station, the post exchange (PX), and the theater. The proposed humidity control system (using humidistats inside and outside) can also be tied into the EMCS for easy monitoring of building humidity control by DEH staff.

If adequate staffing, spare parts, and support are provided to appropriately modify, maintain, and use the EMCS, it can be an invaluable tool for ensuring the continued integrity of the deactivated systems and facilities in the doughboy loop and other affected areas of the post.

If a building no longer has electrical service, telephone access, or a tie into the EMCS, then a radio communications package may be an appropriate alternative. For buildings with continued electrical service and an EMCS, alarm sensors can be integrated directly into the EMCS, precluding the need for radio broadcast of alarm conditions.

The architecture of a radio communications system designed for remote-site building monitoring is shown in Figure I1. The major components of the system include alarm sensors, a dual-tone multifrequency (DTMF) radio digital encoder linked to a high power transmitter (between 2 and 5 Watts), and one base station receiver.

When the system alarm condition is active, an encoded message is transmitted from the remote site to the base receiver. The base receiver is integrated with the appropriate decoder and printer, which provides a hardcopy printout indicating time, date, and message. The message is expressed as a number string that identifies the building and the alarm condition.

The costs for this alarm system, presented in Table I1, do not include any installation expenses. This cost will vary greatly depending on the number of sensors and their locations in the building relative to the radio transmitter. For any particular installation, decisions will have to be made about which alarm conditions are most critical and where to place the sensors. If the sensors are placed in only one location in the building, installation time is reduced but the level of coverage may be inadequate—particularly for smoke detection. It may be reasonable to simply install a few smoke detectors along main corridors. (This approach assumes that these corridors are open to most building spaces and the sensors would detect the smoke shortly after a fire began.) The transmitter should be located to minimize the wiring required between all sensors and the antenna. The antenna should be mounted on a high enough location on the building or facility to ensure reliable reception.

The radio equipment recommended for this application will operate at only one frequency. This frequency must be assigned by the base frequency use manager. In the event that multiple buildings are monitored, signal jamming can be a problem if transmissions are taking place simultaneously. This problem can be avoided by using a timing circuit that delays the transmission of an alarm condition. The systems in different buildings are each governed by different timing delays, which are designed to prevent an overlap of transmitter broadcasts. The timing circuit can generally be provided by the manufacturer of the DTMF encoder. When considering a radio system for alarm condition broadcast, obstacles between the buildings and the base receiver must be evaluated to ensure proper transmission of alarm conditions. Certain frequencies are more susceptible to communication degradation (or failure) due to land masses, distance, weather conditions, buildings, or other obstructions between the transmitter and receiver.

If a deactivated building has electrical power and an operational EMCS, then the appropriate sensors can be interfaced directly with the EMCS. The circuitry required depends on the type of EMCS.

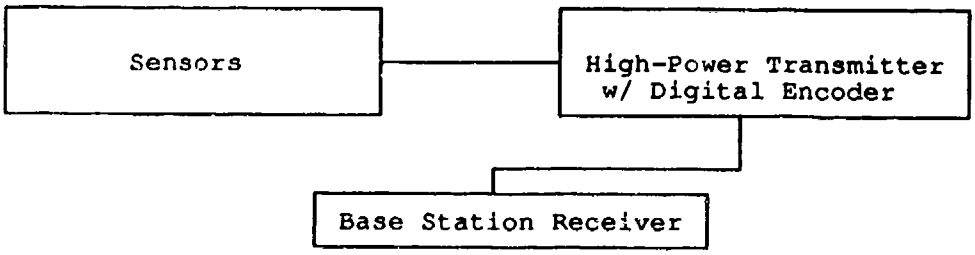

Figure I1. Radio communications system architecture.

Table I1

Radio Alarm System Costs

Sensor and Transmitter Parts List		Cost ($)
2-Watt Utilities Data System transmitter		422.00
Yagi directional antenna		50.00
Gell cell battery with solar charger		100.00
Eight-input digital encoder with timing circuit		129.95
Humidity sensor		300.00
Float switch		20.00
Smoke detector		50.00
Low temperature sensor		5.00
	Sensor Subtotal	1076.95
Receiver Parts List		
2-Watt Receiver		497.00
Omnidirectional antenna		80.00
Digital decoder with printer		848.00
	Receiver Station Subtotal	1425.00
	System Total	2501.95

APPENDIX J:

LAYAWAY UNIT COSTS

ROLLING PIN BARRACKS - COMPONENT COSTS ($/GSF) (RESULTS IN CURRENT DOLLARS) (page 1 of 2)

HEAT — MINIMUM

< 1 YEAR < 45 DAYS

COMPONENT	DEACT	PERIOD	REACT	TOTAL
STRUCTURE	0.000	0.000	0.027	0.027
ROOFING	0.057	0.000	0.027	0.084
EXTERIOR CONST.	0.340	0.005	0.057	0.403
INTERIOR CONST.	0.027	0.000	0.257	0.283
ELEC & MECH EQP.	0.011	0.000	0.052	0.063
PLUMBING	0.025	0.000	0.259	0.285
HEATING SYSTEMS	0.043	0.000	0.065	0.108
TOTALS	0.503	0.005	0.743	1.251

> 1 YEAR < 45 DAYS

COMPONENT	DEACT	PERIOD*	REACT	TOTAL
STRUCTURE	0.000	0.000	0.027	0.027
ROOFING	0.057	0.110	0.279	0.446
EXTERIOR CONST.	0.299	0.330	0.346	0.975
INTERIOR CONST.	0.027	0.200	1.295	1.522
ELEC & MECH EQP.	0.013	0.030	0.093	0.136
PLUMBING	0.025	0.000	0.259	0.285
HEATING SYSTEMS	0.043	0.317	0.005	0.365
TOTALS	0.464	0.987	2.305	3.756

HEAT — PREFERRED

< 1 YEAR < 45 DAYS

COMPONENT	DEACT	PERIOD	REACT	TOTAL
STRUCTURE	0.013	0.010	0.013	0.037
ROOFING	0.084	0.002	0.024	0.110
EXTERIOR CONST.	0.358	0.066	0.013	0.437
INTERIOR CONST.	0.190	0.015	0.013	0.218
ELEC & MECH EQP.	0.021	0.004	0.045	0.070
PLUMBING	0.032	0.002	0.116	0.150
HEATING SYSTEMS	0.044	0.031	0.003	0.078
TOTALS	0.742	0.130	0.227	1.100

> 1 YEAR < 45 DAYS

COMPONENT	DEACT	PERIOD*	REACT	TOTAL
STRUCTURE	0.013	0.010	0.013	0.037
ROOFING	0.084	0.180	0.037	0.301
EXTERIOR CONST.	0.358	0.540	0.235	1.133
INTERIOR CONST.	0.027	0.200	1.073	1.300
ELEC & MECH EQP.	0.021	0.070	0.045	0.136
PLUMBING	0.032	0.020	0.116	0.168
HEATING SYSTEMS	0.044	0.317	0.003	0.364
TOTALS	0.579	1.337	1.523	3.438

NO HEAT — MINIMUM

< 1 YEAR < 45 DAYS

COMPONENT	DEACT	PERIOD	REACT	TOTAL
STRUCTURE	0.000	0.000	0.027	0.027
ROOFING	0.057	0.000	0.027	0.084
EXTERIOR CONST.	0.340	0.005	0.057	0.403
INTERIOR CONST.	0.027	0.000	0.257	0.283
ELEC & MECH EQP.	0.011	0.000	0.052	0.063
PLUMBING	0.025	0.000	0.259	0.285
HEATING SYSTEMS	0.013	0.000	0.152	0.165
TOTALS	0.473	0.005	0.830	1.308

> 1 YEAR < 45 DAYS

COMPONENT	DEACT	PERIOD*	REACT	TOTAL
STRUCTURE	0.000	0.000	0.027	0.027
ROOFING	0.057	0.110	0.279	0.446
EXTERIOR CONST.	0.299	0.330	0.346	0.975
INTERIOR CONST.	0.027	0.200	1.295	1.522
ELEC & MECH EQP.	0.013	0.030	0.093	0.136
PLUMBING	0.025	0.000	0.259	0.285
HEATING SYSTEMS	0.013	0.021	0.130	0.165
TOTALS	0.435	0.691	2.430	3.556

NO HEAT — PREFERRED

< 1 YEAR < 45 DAYS

COMPONENT	DEACT	PERIOD	REACT	TOTAL
STRUCTURE	0.013	0.010	0.013	0.037
ROOFING	0.084	0.002	0.024	0.110
EXTERIOR CONST.	0.358	0.066	0.013	0.437
INTERIOR CONST.	0.190	0.015	0.013	0.218
ELEC & MECH EQP.	0.021	0.004	0.045	0.070
PLUMBING	0.032	0.002	0.116	0.150
HEATING SYSTEMS	0.073	0.002	0.056	0.131
TOTALS	0.771	0.101	0.281	1.153

> 1 YEAR < 45 DAYS

COMPONENT	DEACT	PERIOD*	REACT	TOTAL
STRUCTURE	0.013	0.010	0.013	0.037
ROOFING	0.084	0.180	0.037	0.301
EXTERIOR CONST.	0.358	0.540	0.235	1.133
INTERIOR CONST.	0.027	0.200	1.073	1.300
ELEC & MECH EQP.	0.021	0.070	0.045	0.136
PLUMBING	0.032	0.020	0.116	0.168
HEATING SYSTEMS	0.073	0.021	0.060	0.154
TOTALS	0.608	1.041	1.580	3.229

(*) TOTAL COST OVER 10 YEAR PERIOD

ROLLING PIN AND T BARRACKS - COMPONENT COSTS ($/GSF) [RESULTS IN CURRENT DOLLARS]

	< 1 YEAR > 45 DAYS					> 1 YEAR > 45 DAYS				
	COMPONENT	DEACT	PERIOD	REACT	TOTAL	COMPONENT	DEACT	PERIOD*	REACT	TOTAL
MINIMUM	STRUCTURE	0.000	0.000	0.027	0.027	STRUCTURE	0.000	0.000	0.027	0.027
	ROOFING	0.057	0.000	0.027	0.084	ROOFING	0.057	0.110	0.279	0.446
	EXTERIOR CONST.	0.340	0.005	0.057	0.403	EXTERIOR CONST.	0.299	0.198	0.678	1.176
	INTERIOR CONST.	0.027	0.000	0.257	0.283	INTERIOR CONST.	0.027	0.200	1.960	2.187
	ELEC & MECH EQP.	0.011	0.000	0.052	0.063	ELEC & MECH EQP.	0.013	0.030	0.093	0.136
	PLUMBING	0.025	0.000	0.124	0.149	PLUMBING	0.025	0.000	0.259	0.285
	HEATING SYSTEMS	0.013	0.000	0.152	0.165	HEATING SYSTEMS	0.013	0.021	0.130	0.165
	TOTALS	0.473	0.005	0.695	1.174	TOTALS	0.435	0.559	3.427	4.421
NO HEAT										
	COMPONENT	DEACT	PERIOD	REACT	TOTAL	COMPONENT	DEACT	PERIOD*	REACT	TOTAL
PREFERRED	STRUCTURE	0.013	0.010	0.013	0.037	STRUCTURE	0.013	0.010	0.013	0.037
	ROOFING	0.084	0.002	0.024	0.110	ROOFING	0.084	0.180	0.037	0.301
	EXTERIOR CONST.	0.358	0.066	0.013	0.437	EXTERIOR CONST.	0.358	0.330	0.456	1.144
	INTERIOR CONST.	0.190	0.015	0.013	0.218	INTERIOR CONST.	0.027	0.200	1.518	1.744
	ELEC & MECH EQP.	0.021	0.004	0.045	0.070	ELEC & MECH EQP.	0.021	0.070	0.045	0.136
	PLUMBING	0.032	0.002	0.116	0.150	PLUMBING	0.032	0.020	0.116	0.168
	HEATING SYSTEMS	0.073	0.002	0.056	0.131	HEATING SYSTEMS	0.073	0.021	0.060	0.154
	TOTALS	0.771	0.101	0.281	1.153	TOTALS	0.608	0.831	2.245	3.684

(*) TOTAL COST OVER 10 YEAR PERIOD

FORT DIX - BOILER COSTS ($/BOILER) [RESULTS IN CURRENT DOLLARS]

	< 1 YEAR					> 1 YEAR				
	COMPONENT	DEACT	PERIOD	REACT	TOTAL	COMPONENT	DEACT	PERIOD*	REACT	TOTAL
STANDARD	BOILERS	120670	2030	239400	362100	BOILERS	120670	20300	239400	380370
DO NOTHING	BOILERS	0	0	1280100	1280100	BOILERS	0	0	1280100	1280100

* TOTAL FOR 10 YEAR PERIOD

FORT DIX - GAS DIST. SYSTEM COSTS ($/BUILDING) [RESULTS IN CURRENT DOLLARS]

	< 1 YEAR					> 1 YEAR				
	COMPONENT	DEACT	PERIOD	REACT	TOTAL	COMPONENT	DEACT	PERIOD*	REACT	TOTAL
STANDARD	GAS DIST. SYS.	43.890	18.000	70.490	132.380	GAS DIST. SYS.	43.890	180.000	70.490	294.380

* TOTAL FOR 10 YEAR PERIOD

FORT DIX - UHDS COSTS ($/LF) [RESULTS IN CURRENT DOLLARS]

HEAT

	< 1 YEAR					> 1 YEAR				
	COMPONENT	DEACT	PERIOD	REACT	TOTAL	COMPONENT	DEACT	PERIOD	REACT	TOTAL
MINIMUM	UHDS	0.160	0.075	6.650	6.885	UHDS	0.160	0.075	6.650	6.885
PREFERRED	UHDS	2.341	0.150	0.000	2.491	UHDS	2.341	0.150	0.000	2.491

NO HEAT

	< 1 YEAR					> 1 YEAR				
	COMPONENT	DEACT	PERIOD	REACT	TOTAL	COMPONENT	DEACT	PERIOD	REACT	TOTAL
MINIMUM	UHDS	0.213	0.035	26.600	26.848	UHDS	0.213	0.035	26.600	26.848
PREFERRED	UHDS	2.394	0.070	0.060	2.524	UHDS	2.394	0.070	0.060	2.524

DO NOTHING

COMPONENT	DEACT	PERIOD	REACT	TOTAL	COMPONENT	DEACT	PERIOD	REACT	TOTAL
UHDS	0.000	0.000	266.000	266.000	UHDS	0.000	0.000	266.000	266.000

SANITARY SYSTEMS - TOTAL SYSTEM COST [RESULTS IN CURRENT DOLLARS]

MINIMUM

< 1 YEAR					> 1 YEAR				
COMPONENT	DEACT	PERIOD	REACT	TOTAL	COMPONENT	DEACT	PERIOD*	REACT	TOTAL
WATERLINES	9310	4000	9310	22620	WATERLINES	9310	40000	9310	58620
WELLS & TANKS	6650	4000	7980	18630	WELLS & TANKS	6650	40000	7980	54630
WATER TREATMENT	10640	4000	13300	27940	WATER TREATMENT	10640	40000	13300	63940
WASTEWTR COLLECT	9310	6000	9310	24620	WASTEWTR COLLECT	9310	60000	9310	78620
WASTEWTR TREATMENT	10640	4000	7980	22620	WASTEWTR TREATMENT	10640	40000	7980	58620
FIRE PROTECTION	13300	7000	13300	33600	FIRE PROTECTION	13300	70000	13300	96600
TOTALS	59850	29000	61180	150030	TOTALS	59850	290000	61180	411030

PREFERRED

COMPONENT	DEACT	PERIOD	REACT	TOTAL	COMPONENT	DEACT	PERIOD*	REACT	TOTAL
WATERLINES	15960	7000	9310	32270	WATERLINES	15960	70000	9310	95270
WELLS & TANKS	10640	5000	7980	23620	WELLS & TANKS	10640	50000	7980	68620
WATER TREATMENT	13300	6000	13300	32600	WATER TREATMENT	13300	60000	13300	86600
WASTEWTR COLLECT	13300	7000	9310	29610	WASTEWTR COLLECT	13300	70000	9310	92610
WASTEWTR TREATMENT	13300	6000	7980	27280	WASTEWTR TREATMENT	13300	60000	7980	81280
FIRE PROTECTION	13300	7000	13300	33600	FIRE PROTECTION	13300	70000	13300	96600
TOTALS	79800	38000	61180	178980	TOTALS	79800	380000	61180	520980

* TOTAL FOR 10 YEAR PERIOD

FORT DIX - UNDERGROUND STORAGE TANK COSTS ($/STANDARD TANK) (RESULTS IN CURRENT DOLLARS)

< 1 YEAR < 45 DAYS

	COMPONENT	DEACT	PERIOD	REACT	TOTAL
TEMPORARY	UST	4490	200	4490	9180
PERM IN PLAC	UST	19510	400	13500	33410
DISPOSE/REPL	UST	N/A	N/A	N/A	N/A
STORE/REINST	UST	N/A	N/A	N/A	N/A

> 1 YEAR < 45 DAYS

	COMPONENT	DEACT	PERIOD	REACT	TOTAL
TEMPORARY	UST	N/A	N/A	N/A	N/A
PERM IN PLAC	UST	19510	400	13500	33410
DISPOSE/REPL	UST	14980	0	13010	27990
STORE/REINST	UST	19510	200	8020	27730

< 1 YEAR > 45 DAYS

	COMPONENT	DEACT	PERIOD	REACT	TOTAL
TEMPORARY	UST	4490	200	4490	9180
PERM IN PLAC	UST	19510	400	13500	33410
DISPOSE/REPL	UST	14980	0	13010	27990
STORE/REINST	UST	19510	200	8020	27730

> 1 YEAR > 45 DAYS

	COMPONENT	DEACT	PERIOD	REACT	TOTAL
TEMPORARY	UST	N/A	N/A	N/A	N/A
PERM IN PLAC	UST	19510	400	13500	33410
DISPOSE/REPL	UST	14980	0	13010	27990
STORE/REINST	UST	19510	200	8020	27730

FORT DIX - ELECTRICAL DIST. SYSTEM COSTS ($/FOR WHOLE SYSTEM) (RESULTS IN CURRENT DOLLARS)

< 1 YEAR

	COMPONENT	DEACT	PERIOD	REACT	TOTAL
MINIMUM	ELECT. SYSTEM	3000	1000	8000	12000
PREFERRED	ELECT. SYSTEM	5000	1000	4000	10000

> 1 YEAR

	COMPONENT	DEACT	PERIOD	REACT	TOTAL
MINIMUM	ELECT. SYSTEM	3000	3000	20000	26000
PREFERRED	ELECT. SYSTEM	7000	1000	11000	19000

APPENDIX K:

EQUIVALENT UNIFORM ANNUAL COST (EUAC) SUMMARIES

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN

ALTERNATIVE:= LT1_LT45_MIN_HEAT

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	.50	.50
PERIODIC M&R	1991	.00	.00
HEAT	1991	1.26	1.20
REACTIVATION	1991	.61	.58
ANNUAL TOTAL:=		1.87	1.78

INITIAL COST($):=	.50
PRESENT VALUE($):=	2.28
EQUIVALENT UNIFORM ANNUAL COST($):=	2.50
EUAC PER SQ. FT. ($):=	2.50

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN

ALTERNATIVE:= GT1_LT45_MIN_HEAT

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	.46	.46
PERIODIC M&R	1991	.10	.09
HEAT	1991	1.26	1.20
ANNUAL TOTAL:=		1.36	1.29
PERIODIC M&R	1992	.10	.09
HEAT	1992	1.26	1.14
ANNUAL TOTAL:=		1.36	1.23
PERIODIC M&R	1993	.10	.08
HEAT	1993	1.26	1.08
ANNUAL TOTAL:=		1.36	1.16
PERIODIC M&R	1994	.10	.08
HEAT	1994	1.26	1.03
ANNUAL TOTAL:=		1.36	1.11
PERIODIC M&R	1995	.10	.08
HEAT	1995	1.26	.97
ANNUAL TOTAL:=		1.36	1.05
PERIODIC M&R	1996	.10	.07
HEAT	1996	1.26	.93
ANNUAL TOTAL:=		1.36	1.00
PERIODIC M&R	1997	.10	.07
HEAT	1997	1.26	.88
ANNUAL TOTAL:=		1.36	.95
PERIODIC M&R	1998	.10	.07
HEAT	1998	1.26	.84
ANNUAL TOTAL:=		1.36	.90
PERIODIC M&R	1999	.10	.06
HEAT	1999	1.26	.79
ANNUAL TOTAL:=		1.36	.86
PERIODIC M&R	2000	.10	.06
HEAT	2000	1.26	.75
REACTIVATION	2000	2.31	1.38
ANNUAL TOTAL:=		3.66	2.19

INITIAL COST($):=	.46
PRESENT VALUE($):=	12.20
EQUIVALENT UNIFORM ANNUAL COST($):=	1.88
EUAC PER SQ. FT. ($):=	1.88

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN

ALTERNATIVE:= LT1_LT45_PRF_HEAT

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	.74	.74
PERIODIC M&R	1991	.13	.12
HEAT	1991	1.26	1.20
REACTIVATION	1991	.23	.22
ANNUAL TOTAL:=		1.62	1.54

INITIAL COST($):=	.74
PRESENT VALUE($):=	2.28
EQUIVALENT UNIFORM ANNUAL COST($):=	2.51
EUAC PER SQ. FT. ($):=	2.51

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN

ALTERNATIVE:= GT1_LT45_PRF_HEAT

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	.58	.58
PERIODIC M&R	1991	.13	.12
HEAT	1991	1.26	1.20
ANNUAL TOTAL:=		1.39	1.32
PERIODIC M&R	1992	.13	.12
HEAT	1992	1.26	1.14
ANNUAL TOTAL:=		1.39	1.25
PERIODIC M&R	1993	.13	.11
HEAT	1993	1.26	1.08
ANNUAL TOTAL:=		1.39	1.19
PERIODIC M&R	1994	.13	.11
HEAT	1994	1.26	1.03
ANNUAL TOTAL:=		1.39	1.13
PERIODIC M&R	1995	.13	.10
HEAT	1995	1.26	.97
ANNUAL TOTAL:=		1.39	1.08
PERIODIC M&R	1996	.13	.10
HEAT	1996	1.26	.93
ANNUAL TOTAL:=		1.39	1.02
PERIODIC M&R	1997	.13	.09
HEAT	1997	1.26	.88
ANNUAL TOTAL:=		1.39	.97
PERIODIC M&R	1998	.13	.09
HEAT	1998	1.26	.84
ANNUAL TOTAL:=		1.39	.92
PERIODIC M&R	1999	.13	.08
HEAT	1999	1.26	.79
ANNUAL TOTAL:=		1.39	.88
PERIODIC M&R	2000	.13	.08
HEAT	2000	1.26	.75
REACTIVATION	2000	1.52	.91
ANNUAL TOTAL:=		2.91	1.74

INITIAL COST($):=	.58
PRESENT VALUE($):=	12.09
EQUIVALENT UNIFORM ANNUAL COST($):=	1.86
EUAC PER SQ. FT. ($):=	1.86

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN

ALTERNATIVE:= LT1_LT45_MIN_NOHEAT

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	.47	.47
PERIODIC M&R	1991	.00	.00
REACTIVATION	1991	.70	.66
ANNUAL TOTAL:=		.70	.66

INITIAL COST($):= .47

PRESENT VALUE($):= 1.13

EQUIVALENT UNIFORM ANNUAL COST($):= 1.25

EUAC PER SQ. FT. ($):= 1.25

DATE:= DEC/04/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN

ALTERNATIVE:= GT1_LT45_MIN_NOHEAT

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	.44	.44
PERIODIC M&R	1991	.07	.07
PERIODIC M&R	1992	.07	.06
PERIODIC M&R	1993	.07	.06
PERIODIC M&R	1994	.07	.06
PERIODIC M&R	1995	.07	.05
PERIODIC M&R	1996	.07	.05
PERIODIC M&R	1997	.07	.05
PERIODIC M&R	1998	.07	.05
PERIODIC M&R	1999	.07	.04
PERIODIC M&R	2000	.07	.04
REACTIVATION	2000	3.10	1.85
ANNUAL TOTAL:=		3.16	1.89

INITIAL COST($):= .44

PRESENT VALUE($):= 2.81

EQUIVALENT UNIFORM ANNUAL COST($):= .43

EUAC PER SQ. FT. ($):= .43

DATE:= DEC/04/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN
ALTERNATIVE:= LT1_LT45_PRF_NOHEAT
LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	.77	.77
PERIODIC M&R	1991	.10	.10
REACTIVATION	1991	.28	.27
ANNUAL TOTAL:=		.38	.36

INITIAL COST($):= .77
PRESENT VALUE($):= 1.13
EQUIVALENT UNIFORM ANNUAL COST($):= 1.25
EUAC PER SQ. FT. ($):= 1.25

DATE:= DEC/04/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN
ALTERNATIVE:= GT1_LT45_PRF_NOHEAT
LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	.61	.61
PERIODIC M&R	1991	.10	.10
PERIODIC M&R	1992	.10	.09
PERIODIC M&R	1993	.10	.09
PERIODIC M&R	1994	.10	.08
PERIODIC M&R	1995	.10	.08
PERIODIC M&R	1996	.10	.08
PERIODIC M&R	1997	.10	.07
PERIODIC M&R	1998	.10	.07
PERIODIC M&R	1999	.10	.07
PERIODIC M&R	2000	.10	.06
REACTIVATION	2000	2.02	1.21
ANNUAL TOTAL:=		2.13	1.27

INITIAL COST($):= .61
PRESENT VALUE($):= 2.61
EQUIVALENT UNIFORM ANNUAL COST($):= .40
EUAC PER SQ. FT. ($):= .40

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN

ALTERNATIVE:= LT1_GT45_MIN_NOHEAT

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	.47	.47
PERIODIC M&R	1991	.00	.00
REACTIVATION	1991	.70	.66
ANNUAL TOTAL:=		.70	.66

INITIAL COST($):= .47

PRESENT VALUE($):= 1.13

EQUIVALENT UNIFORM ANNUAL COST($):= 1.25

EUAC PER SQ. FT. ($):= 1.25

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN

ALTERNATIVE:= LT1_GT45_MIN_NOHEAT

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	.47	.47
PERIODIC M&R	1991	.00	.00
REACTIVATION	1991	.83	.79
ANNUAL TOTAL:=		.83	.79

INITIAL COST($):= .47

PRESENT VALUE($):= 1.27

EQUIVALENT UNIFORM ANNUAL COST($):= 1.39

EUAC PER SQ. FT. ($):= 1.39

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN

ALTERNATIVE:= GT1_GT45_MIN_NOHEAT

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	.44	.44
PERIODIC M&R	1991	.06	.05
PERIODIC M&R	1992	.06	.05
PERIODIC M&R	1993	.06	.05
PERIODIC M&R	1994	.06	.05
PERIODIC M&R	1995	.06	.04
PERIODIC M&R	1996	.06	.04
PERIODIC M&R	1997	.06	.04
PERIODIC M&R	1998	.06	.04
PERIODIC M&R	1999	.06	.04
PERIODIC M&R	2000	.06	.03
REACTIVATION	2000	3.43	2.05
ANNUAL TOTAL:=		3.48	2.09

INITIAL COST($):=	.44
PRESENT VALUE($):=	2.91
EQUIVALENT UNIFORM ANNUAL COST($):=	.45
EUAC PER SQ. FT. ($):=	.45

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN

ALTERNATIVE:= LT1_GT45_PRF_NOHEAT

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	.77	.77
PERIODIC M&R	1991	.10	.10
REACTIVATION	1991	.28	.27
ANNUAL TOTAL:=		.38	.36

INITIAL COST($):=	.77
PRESENT VALUE($):=	1.13
EQUIVALENT UNIFORM ANNUAL COST($):=	1.25
EUAC PER SQ. FT. ($):=	1.25

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN

ALTERNATIVE:= GT1_GT45_PRF_NOHEAT

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	.61	.61
PERIODIC M&R	1991	.08	.08
PERIODIC M&R	1992	.08	.07
PERIODIC M&R	1993	.08	.07
PERIODIC M&R	1994	.08	.07
PERIODIC M&R	1995	.08	.06
PERIODIC M&R	1996	.08	.06
PERIODIC M&R	1997	.08	.06
PERIODIC M&R	1998	.08	.06
PERIODIC M&R	1999	.08	.05
PERIODIC M&R	2000	.08	.05
REACTIVATION	2000	2.24	1.34
ANNUAL TOTAL:=		2.33	1.39

INITIAL COST($):=	.61
PRESENT VALUE($):=	2.59
EQUIVALENT UNIFORM ANNUAL COST($):=	.40
EUAC PER SQ. FT. ($):=	.40

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN

ALTERNATIVE:= LT1_DO NOTHING

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	.00	.00
PERIODIC M&R	1991	.00	.00
REACTIVATION	1991	33.34	31.67
ANNUAL TOTAL:=		33.34	31.67

INITIAL COST($):=	.00
PRESENT VALUE($):=	31.67
EQUIVALENT UNIFORM ANNUAL COST($):=	34.84
EUAC PER SQ. FT. ($):=	34.84

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R-PIN

ALTERNATIVE:= GT1_DO NOTHING

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	.00	.00
PERIODIC M&R	1991	.00	.00
PERIODIC M&R	1992	.00	.00
PERIODIC M&R	1993	.00	.00
PERIODIC M&R	1994	.00	.00
PERIODIC M&R	1995	.00	.00
PERIODIC M&R	1996	.00	.00
PERIODIC M&R	1997	.00	.00
PERIODIC M&R	1998	.00	.00
PERIODIC M&R	1999	.00	.00
PERIODIC M&R	2000	.00	.00
REACTIVATION	2000	40.11	24.02
ANNUAL TOTAL:=		40.11	24.02

INITIAL COST($):=	.00
PRESENT VALUE($):=	24.02
EQUIVALENT UNIFORM ANNUAL COST($):=	3.70
EUAC PER SQ. FT. ($):=	3.70

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UHDS

ALTERNATIVE:= LT1_MIN_HEAT

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	.16	.16
PERIODIC M&R	1991	.08	.07
REACTIVATION	1991	6.65	6.32
ANNUAL TOTAL:=		6.72	6.39

INITIAL COST($):=	.16
PRESENT VALUE($):=	6.55
EQUIVALENT UNIFORM ANNUAL COST($):=	7.20
EUAC PER L.F. ($):=	7.20

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UHDS

ALTERNATIVE:= GT1_MIN_HEAT

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	.16	.16
PERIODIC M&R	1991	.08	.07
PERIODIC M&R	1992	.08	.07
PERIODIC M&R	1993	.08	.06
PERIODIC M&R	1994	.08	.06
PERIODIC M&R	1995	.08	.06
PERIODIC M&R	1996	.08	.06
PERIODIC M&R	1997	.08	.05
PERIODIC M&R	1998	.08	.05
PERIODIC M&R	1999	.08	.05
PERIODIC M&R	2000	.08	.04
REACTIVATION	2000	6.65	3.98
ANNUAL TOTAL:=		6.72	4.03

INITIAL COST($):= .16
PRESENT VALUE($):= 4.71
EQUIVALENT UNIFORM ANNUAL COST($):= .73
EUAC PER L.F. ($):= .73

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UHDS

ALTERNATIVE:= LT1_PRF_HEAT

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	2.34	2.34
PERIODIC M&R	1991	.15	.14
REACTIVATION	1991	.00	.00
ANNUAL TOTAL:=		.15	.14

INITIAL COST($):= 2.34
PRESENT VALUE($):= 2.48
EQUIVALENT UNIFORM ANNUAL COST($):= 2.73
EUAC PER L.F. ($):= 2.73

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UHDS

ALTERNATIVE:= GT1_PRF_HEAT

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	2.34	2.34
PERIODIC M&R	1991	.15	.14
PERIODIC M&R	1992	.15	.14
PERIODIC M&R	1993	.15	.13
PERIODIC M&R	1994	.15	.12
PERIODIC M&R	1995	.15	.12
PERIODIC M&R	1996	.15	.11
PERIODIC M&R	1997	.15	.10
PERIODIC M&R	1998	.15	.10
PERIODIC M&R	1999	.15	.09
PERIODIC M&R	2000	.15	.09
REACTIVATION	2000	.00	.00
ANNUAL TOTAL:=		.15	.09

INITIAL COST($):=	2.34
PRESENT VALUE($):=	3.48
EQUIVALENT UNIFORM ANNUAL COST($):=	.54
EUAC PER L.F. ($):=	.54

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UHDS

ALTERNATIVE:= LT1_MIN_NOHEAT

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	.21	.21
PERIODIC M&R	1991	.04	.03
REACTIVATION	1991	26.60	25.27
ANNUAL TOTAL:=		26.64	25.30

INITIAL COST($):=	.21
PRESENT VALUE($):=	25.52
EQUIVALENT UNIFORM ANNUAL COST($):=	28.07
EUAC PER L.F. ($):=	28.07

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UHDS

ALTERNATIVE:= GT1_MIN_NOHEAT

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	.21	.21
PERIODIC M&R	1991	.04	.03
PERIODIC M&R	1992	.04	.03
PERIODIC M&R	1993	.04	.03
PERIODIC M&R	1994	.04	.03
PERIODIC M&R	1995	.04	.03
PERIODIC M&R	1996	.04	.03
PERIODIC M&R	1997	.04	.02
PERIODIC M&R	1998	.04	.02
PERIODIC M&R	1999	.04	.02
PERIODIC M&R	2000	.04	.02
REACTIVATION	2000	26.60	15.93
ANNUAL TOTAL:=		26.64	15.95

INITIAL COST($):=	.21
PRESENT VALUE($):=	16.41
EQUIVALENT UNIFORM ANNUAL COST($):=	2.53
EUAC PER L.F. ($):=	2.53

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UHDS

ALTERNATIVE:= LT1_PRF_NOHEAT

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	2.39	2.39
PERIODIC M&R	1991	.07	.07
REACTIVATION	1991	.06	.06
ANNUAL TOTAL:=		.13	.12

INITIAL COST($):=	2.39
PRESENT VALUE($):=	2.52
EQUIVALENT UNIFORM ANNUAL COST($):=	2.77
EUAC PER L.F. ($):=	2.77

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UHDS

ALTERNATIVE:= GT1_PRF_NOHEAT

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	2.39	2.39
PERIODIC M&R	1991	.07	.07
PERIODIC M&R	1992	.07	.06
PERIODIC M&R	1993	.07	.06
PERIODIC M&R	1994	.07	.06
PERIODIC M&R	1995	.07	.05
PERIODIC M&R	1996	.07	.05
PERIODIC M&R	1997	.07	.05
PERIODIC M&R	1998	.07	.05
PERIODIC M&R	1999	.07	.04
PERIODIC M&R	2000	.07	.04
REACTIVATION	2000	.06	.04
ANNUAL TOTAL:=		.13	.08

INITIAL COST($):=	2.39
PRESENT VALUE($):=	2.96
EQUIVALENT UNIFORM ANNUAL COST($):=	.46
EUAC PER L.F. ($):=	.46

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UHDS

ALTERNATIVE:= LT1_DO NOTHING

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	.00	.00
PERIODIC M&R	1991	.00	.00
REACTIVATION	1991	266.00	252.70
ANNUAL TOTAL:=		266.00	252.70

INITIAL COST($):=	.00
PRESENT VALUE($):=	252.70
EQUIVALENT UNIFORM ANNUAL COST($):=	277.97
EUAC PER L.F. ($):=	277.97

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UHDS
ALTERNATIVE:= GT1_DO NOTHING
LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	.00	.00
PERIODIC M&R	1991	.00	.00
PERIODIC M&R	1992	.00	.00
PERIODIC M&R	1993	.00	.00
PERIODIC M&R	1994	.00	.00
PERIODIC M&R	1995	.00	.00
PERIODIC M&R	1996	.00	.00
PERIODIC M&R	1997	.00	.00
PERIODIC M&R	1998	.00	.00
PERIODIC M&R	1999	.00	.00
PERIODIC M&R	2000	.00	.00
REACTIVATION	2000	266.00	159.26
ANNUAL TOTAL:=		266.00	159.26

INITIAL COST($):=	.00
PRESENT VALUE($):=	159.26
EQUIVALENT UNIFORM ANNUAL COST($):=	24.52
EUAC PER L.F. ($):=	24.52

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UST
ALTERNATIVE:= LT1_TEMP
LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	4490.00	4490.00
PERIODIC M&R	1991	200.00	190.00
REACTIVATION	1991	4490.00	4265.50
ANNUAL TOTAL:=		4690.00	4455.50

INITIAL COST($):=	4490.00
PRESENT VALUE($):=	8945.50
EQUIVALENT UNIFORM ANNUAL COST($):=	9840.05
EUAC PER TANK ($):=	9840.05

DATE:= NOV/27/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UST

ALTERNATIVE:= LT1_PERM IN PLACE

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	19510.00	19510.00
PERIODIC M&R	1991	400.00	380.00
REACTIVATION	1991	13500.00	12825.00
ANNUAL TOTAL:=		13900.00	13205.00

INITIAL COST($):=	19510.00
PRESENT VALUE($):=	32715.00
EQUIVALENT UNIFORM ANNUAL COST($):=	35986.49
EUAC PER TANK ($):=	35986.49

DATE:= NOV/27/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UST

ALTERNATIVE:= GT1_PERM IN PLACE

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	19510.00	19510.00
PERIODIC M&R	1991	400.00	380.00
PERIODIC M&R	1992	400.00	361.00
PERIODIC M&R	1993	400.00	342.95
PERIODIC M&R	1994	400.00	325.80
PERIODIC M&R	1995	400.00	309.51
PERIODIC M&R	1996	400.00	294.04
PERIODIC M&R	1997	400.00	279.33
PERIODIC M&R	1998	400.00	265.37
PERIODIC M&R	1999	400.00	252.10
PERIODIC M&R	2000	400.00	239.49
REACTIVATION	2000	13500.00	8082.94
ANNUAL TOTAL:=		13900.00	8322.44

INITIAL COST($):=	19510.00
PRESENT VALUE($):=	30642.54
EQUIVALENT UNIFORM ANNUAL COST($):=	4717.82
EUAC PER TANK ($):=	4717.82

DATE:= NOV/27/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UST
ALTERNATIVE:= LT1_DISPOSE/REPLACE
LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	14980.00	14980.00
PERIODIC M&R	1991	.00	.00
REACTIVATION	1991	13010.00	12359.50
ANNUAL TOTAL:=		13010.00	12359.50

INITIAL COST($):=	14980.00
PRESENT VALUE($):=	27339.50
EQUIVALENT UNIFORM ANNUAL COST($):=	30073.44
EUAC PER TANK ($):=	30073.44

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UST
ALTERNATIVE:= GT1_DISPOSE/REPLACE
LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	14980.00	14980.00
PERIODIC M&R	1991	.00	.00
PERIODIC M&R	1992	.00	.00
PERIODIC M&R	1993	.00	.00
PERIODIC M&R	1994	.00	.00
PERIODIC M&R	1995	.00	.00
PERIODIC M&R	1996	.00	.00
PERIODIC M&R	1997	.00	.00
PERIODIC M&R	1998	.00	.00
PERIODIC M&R	1999	.00	.00
PERIODIC M&R	2000	.00	.00
REACTIVATION	2000	13010.00	7789.56
ANNUAL TOTAL:=		13010.00	7789.56

INITIAL COST($):=	14980.00
PRESENT VALUE($):=	22769.56
EQUIVALENT UNIFORM ANNUAL COST($):=	3505.67
EUAC PER TANK ($):=	3505.67

DATE:= NOV/27/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UST

ALTERNATIVE:= LT1_STORE/REINSTALL

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	19510.00	19510.00
PERIODIC M&R	1991	200.00	190.00
REACTIVATION	1991	8020.00	7619.00
ANNUAL TOTAL:=		8220.00	7809.00

INITIAL COST($):=	19510.00
PRESENT VALUE($):=	27319.00
EQUIVALENT UNIFORM ANNUAL COST($):=	30050.89
EUAC PER TANK ($):=	30050.89

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=UST

ALTERNATIVE:= GT1_STORE/REINSTALL

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	19510.00	19510.00
PERIODIC M&R	1991	200.00	190.00
PERIODIC M&R	1992	200.00	180.50
PERIODIC M&R	1993	200.00	171.47
PERIODIC M&R	1994	200.00	162.90
PERIODIC M&R	1995	200.00	154.76
PERIODIC M&R	1996	200.00	147.02
PERIODIC M&R	1997	200.00	139.67
PERIODIC M&R	1998	200.00	132.68
PERIODIC M&R	1999	200.00	126.05
PERIODIC M&R	2000	200.00	119.75
REACTIVATION	2000	8020.00	4801.87
ANNUAL TOTAL:=		8220.00	4921.61

INITIAL COST($):=	19510.00
PRESENT VALUE($):=	25836.67
EQUIVALENT UNIFORM ANNUAL COST($):=	3977.89
EUAC PER TANK ($):=	3977.89

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=SANITARY

ALTERNATIVE:= LT1_MIN

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	59850.00	59850.00
PERIODIC M&R	1991	29000.00	27550.00
REACTIVATION	1991	61180.00	58121.00
ANNUAL TOTAL:=		90180.00	85670.99

INITIAL COST($):=	59350.00
PRESENT VALUE($):=	145521.00
EQUIVALENT UNIFORM ANNUAL COST($):=	160073.10
EUAC FOR SYSTEM ($):=	160073.10

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=SANITARY

ALTERNATIVE:= GT1·MIN

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	59850.00	59850.00
PERIODIC M&R	1991	29000.00	27550.00
PERIODIC M&R	1992	29000.00	26172.50
PERIODIC M&R	1993	29000.00	24863.87
PERIODIC M&R	1994	29000.00	23620.67
PERIODIC M&R	1995	29000.00	22439.64
PERIODIC M&R	1996	29000.00	21317.66
PERIODIC M&R	1997	29000.00	20251.77
PERIODIC M&R	1998	29000.00	19239.18
PERIODIC M&R	1999	29000.00	18277.22
PERIODIC M&R	2000	29000.00	17363.36
REACTIVATION	2000	61180.00	36630.70
ANNUAL TOTAL:=		90180.00	53994.06

INITIAL COST($):=	59850.00
PRESENT VALUE($):=	317576.60
EQUIVALENT UNIFORM ANNUAL COST($):=	48895.08
EUAC FOR SYSTEM ($):=	48895.08

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=SANITARY

ALTERNATIVE:= LT1_PRF

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	79800.00	79800.00
PERIODIC M&R	1991	38000.00	36100.00
REACTIVATION	1991	61180.00	58121.00
ANNUAL TOTAL:=		99180.00	94220.99

INITIAL COST($):= 79800.00
PRESENT VALUE($):= 174021.00
EQUIVALENT UNIFORM ANNUAL COST($):= 191423.10
EUAC FOR SYSTEM ($):= 191423.10

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=SANITARY

ALTERNATIVE:= GT1_PRF

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	79800.00	79800.00
PERIODIC M&R	1991	38000.00	36100.00
PERIODIC M&R	1992	38000.00	34295.00
PERIODIC M&R	1993	38000.00	32580.24
PERIODIC M&R	1994	38000.00	30951.23
PERIODIC M&R	1995	38000.00	29403.67
PERIODIC M&R	1996	38000.00	27933.48
PERIODIC M&R	1997	38000.00	26536.81
PERIODIC M&R	1998	38000.00	25209.96
PERIODIC M&R	1999	38000.00	23949.46
PERIODIC M&R	2000	38000.00	22751.99
REACTIVATION	2000	61180.00	36630.70
ANNUAL TOTAL:=		99180.00	59382.69

INITIAL COST($):= 79800.00
PRESENT VALUE($):= 406142.60
EQUIVALENT UNIFORM ANNUAL COST($):= 62530.98
EUAC FOR SYSTEM ($):= 62530.98

DATE:= NOV/27/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=ELECTRICAL DIST.

ALTERNATIVE:= LT1_MIN

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	3000.00	3000.00
PERIODIC M&R	1991	1000.00	950.00
REACTIVATION	1991	8000.00	7600.00
ANNUAL TOTAL:=		9000.00	8550.00

INITIAL COST($):= 3000.00
PRESENT VALUE($):= 11550.00
EQUIVALENT UNIFORM ANNUAL COST($):= 12705.00
EUAC FOR SYSTEM ($):= 12705.00

DATE:= NOV/27/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=ELECTRICAL DIST.

ALTERNATIVE:= GT1_MIN

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	3000.00	3000.00
PERIODIC M&R	1991	3000.00	2850.00
PERIODIC M&R	1992	3000.00	2707.50
PERIODIC M&R	1993	3000.00	2572.12
PERIODIC M&R	1994	3000.00	2443.52
PERIODIC M&R	1995	3000.00	2321.34
PERIODIC M&R	1996	3000.00	2205.27
PERIODIC M&R	1997	3000.00	2095.01
PERIODIC M&R	1998	3000.00	1990.26
PERIODIC M&R	1999	3000.00	1890.75
PERIODIC M&R	2000	3000.00	1796.21
REACTIVATION	2000	20000.00	11974.73
ANNUAL TOTAL:=		23000.00	13770.94

INITIAL COST($):= 3000.00
PRESENT VALUE($):= 37846.72
EQUIVALENT UNIFORM ANNUAL COST($):= 5827.00
EUAC FOR SYSTEM ($):= 5827.00

DATE:= NOV/27/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=ELECTRICAL DIST.

ALTERNATIVE:= LT1_PRF

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	5000.00	5000.00
PERIODIC M&R	1991	1000.00	950.00
REACTIVATION	1991	4000.00	3800.00
ANNUAL TOTAL:=		5000.00	4750.00

INITIAL COST($):=	5000.00
PRESENT VALUE($):=	9750.00
EQUIVALENT UNIFORM ANNUAL COST($):=	10725.00
EUAC FOR SYSTEM ($):=	10725.00

DATE:= NOV/27/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=ELECTRICAL DIST.

ALTERNATIVE:= GT1_PRF

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	7000.00	7000.00
PERIODIC M&R	1991	1000.00	950.00
PERIODIC M&R	1992	1000.00	902.50
PERIODIC M&R	1993	1000.00	857.37
PERIODIC M&R	1994	1000.00	814.51
PERIODIC M&R	1995	1000.00	773.78
PERIODIC M&R	1996	1000.00	735.09
PERIODIC M&R	1997	1000.00	698.34
PERIODIC M&R	1998	1000.00	663.42
PERIODIC M&R	1999	1000.00	630.25
PERIODIC M&R	2000	1000.00	598.74
REACTIVATION	2000	11000.00	6586.10
ANNUAL TOTAL:=		12000.00	7184.84

INITIAL COST($):=	7000.00
PRESENT VALUE($):=	21210.10
EQUIVALENT UNIFORM ANNUAL COST($):=	3265.57
EUAC FOR SYSTEM ($):=	3265.57

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=BOILERS

ALTERNATIVE:= LT1_STANDARD

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	120670.00	120670.00
PERIODIC M&R	1991	2030.00	1928.50
REACTIVATION	1991	239400.00	227430.00
ANNUAL TOTAL:=		241430.00	229358.50

INITIAL COST($):=	120670.00
PRESENT VALUE($):=	350028.50
EQUIVALENT UNIFORM ANNUAL COST($):=	385031.30
EUAC PER BOILER ($):=	385031.30

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=BOILERS

ALTERNATIVE:= GT1_STANDARD

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST($)	PRESENT VALUE($)
DEACTIVATION	1990	120670.00	120670.00
PERIODIC M&R	1991	2030.00	1928.50
PERIODIC M&R	1992	2030.00	1832.07
PERIODIC M&R	1993	2030.00	1740.47
PERIODIC M&R	1994	2030.00	1653.45
PERIODIC M&R	1995	2030.00	1570.77
PERIODIC M&R	1996	2030.00	1492.24
PERIODIC M&R	1997	2030.00	1417.62
PERIODIC M&R	1998	2030.00	1346.74
PERIODIC M&R	1999	2030.00	1279.41
PERIODIC M&R	2000	2030.00	1215.44
REACTIVATION	2000	239400.00	143337.50
ANNUAL TOTAL:=		241430.00	144553.00

INITIAL COST($):=	120670.00
PRESENT VALUE($):=	279484.30
EQUIVALENT UNIFORM ANNUAL COST($):=	43030.27
EUAC PER BOILER ($):=	43030.27

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=BOILERS

ALTERNATIVE:= LT1_DO NOTHING

LIFE OF ALTERNATIVE:= 1 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	.00	.00
PERIODIC M&R	1991	.00	.00
REACTIVATION	1991	1280100.00	1216095.00
ANNUAL TOTAL:=		1280100.00	1216095.00

INITIAL COST($):=	.00
PRESENT VALUE($):=	1216095.00
EQUIVALENT UNIFORM ANNUAL COST($):=	1337704.00
EUAC PER BOILER ($):=	1337704.00

DATE:= NOV/26/1990 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=BOILERS

ALTERNATIVE:= GT1_DO NOTHING

LIFE OF ALTERNATIVE:= 11 INTEREST RATE:= 10.0 INFLATION RATE:= 4.5

M&R ACTIVITY	YEAR	COST(S)	PRESENT VALUE($)
DEACTIVATION	1990	.00	.00
PERIODIC M&R	1991	.00	.00
PERIODIC M&R	1992	.00	.00
PERIODIC M&R	1993	.00	.00
PERIODIC M&R	1994	.00	.00
PERIODIC M&R	1995	.00	.00
PERIODIC M&R	1996	.00	.00
PERIODIC M&R	1997	.00	.00
PERIODIC M&R	1998	.00	.00
PERIODIC M&R	1999	.00	.00
PERIODIC M&R	2000	.00	.00
REACTIVATION	2000	1280100.00	766442.60
ANNUAL TOTAL:=		1280100.00	766442.60

INITIAL COST($):=	.00
PRESENT VALUE($):=	766442.60
EQUIVALENT UNIFORM ANNUAL COST($):=	118003.90
EUAC PER BOILER ($):=	118003.90

ABBREVIATIONS

A/E	architectural/engineers
ADP	automatic data processing
AHU	air-handler unit
AMC	U.S. Army Materiel Command
ANSI	American National Standards Institute
AR	Army Regulation
ARMA	Asphalt Roofing Manufacturers Association
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BUR	built-up roof
CFC	chlorofluorocarbon
DEH	Directorate of Engineering and Housing
DOD	Department of Defense
DTMF	dual-tone multifrequency
DX	direct expansion
EMCS	emergency monitoring and control system
EMS	engineered management system
EPA	Environmental Protection Agency
EPDM	ethylene-propylene-diene monomer
EPRI	Electrical Power Research Institute
ETAC	U.S. Force Environmental Technical Applications Center
EUAC	Equivalent Uniform Annual Cost
Fed Spec	Federal Specification
FID	field interface device
FRP	fiberglass-reinforced plastic
GPM	gallons per minute
HSWA	Hazardous Solid Waste Amendments
I/I	infiltration/inflow
IAQ	indoor air quality
IEEE	Institute of Electrical and Electronic Engineers
LPI	Leak Potential Index
M&R	Maintenance and Repair

ABBREVIATIONS (Cont'd)

MACOM	Major Army Command
MIL	Military Specification
MOGAS	motor gasoline
MRPM	Maintenance Resource Prediction Model
NASA	National Aeronatics and Space Administration
NCEL	Naval Civil Engineering Laboratory
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NJDEP	New Jersey Department of Environmental Protection
NPS	National Park Service
NRCA	National Roofing Contractors Association
OSHA	Occupational Safety and Health Administration
PM	preventive maintenance
RCRA	Resource Conservation and Recovery Act
SHDP	Steam Heat Distribution Program
TM	technical manual
TR	technical report
TRADOC	U.S. Army Training and Doctrine Command
USACERL	U.S. Army Construction Engineering Research Laboratory
USAEHSC	U.S. Army Engineering and Housing Support Center
UST	underground storage tank